PB195338

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
Springfield, Va. 22151

STANDARD TITLE PAGE FOR TECHNICAL REPORTS

1. Report No. APTD-0592

2. Govt. Accession No.

3. Recipient's Catalog No.

4. Title and Subtitle
A Study of Indoor-Outdoor Air Pollutant Relationships
Volumes I and II

5. Report Date
May 1970

6. Performing Organization Code

7. Author(s)
J. E. Yocom, William A. Cote, and William L. Clink

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
The Research Corporation of New England
P. O. Box 3335
Hartford, Connecticut 06103

10. Project/Task/Work Unit No.

11. Contract/Grant No.
CPA 22-69-14

12. Sponsoring Agency Name and Address
DHEW, PHS, EHS, National Air Pollution Control Administration
411 West Chapel Hill Street Technical Center
Durham, North Carolina 27701

13. Type of Report & Period Covered

14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstracts Suspended particulate material, soiling particulate material, and carbon monoxide and sulfur dioxide gases were measured at pairs of older public buildings and newer air conditioned office buildings, and private homes in the area of greater Hartford, Connecticut during ~~the~~ three seasons, summer and fall of 1969, and the following winter, 1970. A more limited study of pollutants inside and outside of four private homes was also conducted, during the late winter of 1969, and is reported in volume II. Suspended particulate matter readily penetrated the private homes in the summer. Penetration was more of the order of 50 percent in the other buildings and seasons, decreasing to as low as 20 percent at one public building in the winter. Normal daily activity and traffic and seasonal factors greatly influenced the measured levels of suspended particulates, both outdoors and, to a lesser extent, indoors. The organic fraction of suspended particulates readily penetrated all structures and significant quantities may have been generated indoors. The lead fraction of suspended particulates outdoors was strongly dependent upon traffic factors and penetrated structures only marginally better than the parent particulate. Soiling index measurements indicate low soiling potential generally, with 80 to 90 percent of outdoor ~~(continued on other side)~~

17. Key Words and Document Analysis. (a). Descriptors

Air pollution
Public buildings
Office buildings
Houses
Aerosols
Dust
Carbon monoxide
Sulfur dioxide
Air conditioning
Seasonal variations
Penetration
Fluid infiltration
Diurnal variations
Vehicular traffic
Lead inorganic compounds
Gas Sampling
Ventilation
Vehicular tunnels
Parking facilities
Subsurface structures
Particle size

17b. Identifiers/Open-Ended Terms

Indoor
Outdoor
Organic fraction
Suspended particulate
Soiling index

17c. COSATI Field/Group 13/02

18. Distribution Statement
Unlimited

19. Security Class (This Report)
UNCLASSIFIED

20. Security Class. (This Page)
UNCLASSIFIED

21. No. of Pages
155

22. Price

levels appearing indoors, except at one public building in winter when indoor concentration dropped to 50 percent of outdoors. The use of a polyurethane foam prefilter to remove non-respirable suspended particulates proved unreliable and was abandoned after the summer program. Carbon monoxide readily penetrates all the structures and anomalies appear readily relatable to source and ventilation variables and, in particular its concentration may be altered by properly phased adjustments in external ventilation. From carbon monoxide measurements there appears to be little detectable influence of a submerged roadway upon an air-rights structure, other than through its contribution to general pollutant concentration outdoors, or of an underlying parking garage upon an air conditioned building above. Natural ventilation rates in the selected residences, under closed conditions, were almost identical (ventilation time constant - 90 minutes in late summer, about 60 minutes in late fall and winter) despite differences in style and construction. Generally, from 50 to 100 percent of sulfur dioxide outside penetrated the structures when it existed in quantities measurable by the equipment, except at one residence where penetration dropped by a factor of two in winter and additionally by a factor of four at night. An overall survey of the ratios of inside to outside concentration indicates that particulates least readily penetrate structures but that specific components penetrate more readily or are re-suspended inside, that sulfur dioxide suffers some loss during penetration, and that carbon monoxide is least affected by penetration and may be enhanced under certain circumstances.

VOLUME I: SUMMARY REPORT

FINAL REPORT
CONTRACT NO. CPA 22-69-14

Prepared for the

NATIONAL AIR POLLUTION
CONTROL ADMINISTRATION

Prepared by:

John E. Yocom, Principal Investigator
William L. Clink, Research Scientist
William A. Cote, Research Engineer

May, 1970

THE RESEARCH CORPORATION of New England
P. O. Box 3335
Hartford, Connecticut 06103

CONTENTS

Page

1.0 Introduction 1

2.0 Summary and Conclusions 3

3.0 Description of Sampling Program 6

3.1 Sampling Plan

  3.1.1 General Description

  3.1.2 Pollutants to be Measured 7

  3.1.3 Sampling Schedule 10

3.2 Instrumentation

  3.2.1 Measurement Concept

  3.2.2 Instrumentation Selection and Specifications 12

  3.2.3 Description of Package and Components 15

  3.2.4 Recording Chart Format 23

  3.2.5 Maintenance 24

  3.2.6 Calibration Techniques and Assigned Accuracies 25

  3.2.7 Performance 27

  3.2.8 Program Changes 29

  3.2.9 General Comments on Instrumentation 30

3.3 Structures Sampled 32

  3.3.1 Public Buildings

  3.3.2 Office Buildings 33

  3.3.3 Private Homes 35

4.0 Field Operations 37

5.0 Sampling Results 41

Contents, continued.

Page

5.1 Suspended Particulates 42

5.2 Soiling Particulates 63

5.3 Gaseous Pollutants 85

6.0 Discussion of Results 105

6.1 Suspended Particulate

6.2 Soiling Particulate 111

6.3 Carbon Monoxide 113

6.4 Sulfur Dioxide 115

6.5 Summary 117

7.0 Acknowledgements 122

1.0 INTRODUCTION

This report presents the results of a series of sampling programs conducted during the past 21 months as a study of indoor-outdoor air pollutant relationships. Field activities in the main portion of the study ran through the three seasons of summer, fall and winter, from July 1969 to March 1970. An abbreviated supplementary study was based on measurements during February and March of 1969.

Work on the main portion of the program was conducted at three pairs of buildings in central Hartford and in East Hartford. The object of the study was to measure concentrations of four different pollutants (suspended particulate matter, soiling particulate matter, carbon monoxide and sulfur dioxide) simultaneously at four locations in and around three pairs of structures (two indoor and two outdoor at each structure) and to evaluate various building parameters that may effect indoor-outdoor relationships. The results are summarized in this first volume of a two volume final report on the studies. Associated with Volume I are three data supplements of, respectively, the summer sampling program (Yocom, 1970), the fall sampling program, and the winter sampling program.

A supplemental study, (Yocom, 1969) preceeded the main study. This was a brief program of limited scope in which carbon monoxide

---

1969: Yocom, J.E., W.A. Cote and W.L. Clink, "Summary Report of A Study of Indoor/Outdoor Air Pollutant Relationships (Supplemental Study) The Travelers Research Corporation, June, 1969.

1970: Yocom, J.E., W.L. Clink and W.A. Cote, "Summary Report on a Study of Indoor/Outdoor Air Pollutant Relationships (Summer Sampling Program) The Travelers Research Corp., March, 1970.

from p.1

→ In a related study,

→ Carbon monoxide

was measured inside and outside of a pair of gas fueled homes and, additionally, sulfur dioxide and soiling particulates at a pair of coal fueled homes. Results of the supplemental study are published, complete with data, in the second volume of this report.

2.0 SUMMARY AND CONCLUSIONS

The purpose of this study was to gather air quality data for four pollutants inside and outside of three pairs of structures for different seasons of the year. This report presents those results for the three seasons, summer and fall of 1969, and the following winter, 1970. Suspended particulate material, soiling particulate material, and carbon monoxide and sulfur dioxide gases were measured at pairs of older public buildings and newer air conditioned office buildings, and private homes in the area of greater Hartford, Connecticut. A more limited study of pollutants inside and outside of four private homes was also conducted, during the late winter of 1969, and is reported in a companion volume to this report.

Two self-contained and portable instrument packages were constructed for the measurement program. The major components of each trailer package were a central vacuum pump for drawing air samples through particulate collection filters, four paper-tape soiling samplers, a conductimetric analyzer for sulfur dioxide, an infrared analyzer for carbon monoxide, a master control unit for cycling the sampling through four sample points and to establish 2-hour and 12-hour sampling intervals, and supporting apparatus to make the trailer self-contained. In separate packages, two particle-size fractionating samplers were operated sequentially at each building during fall and winter to assess the size spectrum of suspended particulates inside and out.

Each pair of buildings was sampled simultaneously for a two-week period. Four sampling points were selected at each structure, two outside and two inside. Filters for suspended particulate matter were placed in "birdhouse" size structures at each of the four sampling points, and the air flow lines connected to the externally located instrumented trailers. Suspended particulate samples were collected for 12-hour day and night periods, beginning at 7:00 a.m. and 7:00 p.m. and soiling particulate samples for 2-hour periods. Gases were sampled for 5-minute periods sequentially at each sample point, repeating three times per hour.

The salient conclusions we have drawn from the data collected in these experiments are:

(1) suspended particulate matter readily penetrated the private homes ~~in this study~~ in the summer. Penetration was more of the order of 50 percent in the other buildings and other seasons, decreasing to as low as 20 percent at one public building in the winter;

(2) normal daily activity and traffic and seasonal factors greatly influenced the measured levels of suspended particulates, both outdoors and, to a lesser extent, indoors;

(3) the organic fraction of suspended particulates readily penetrated all structures and significant quantities may have been generated indoors;

(4) the lead fraction of suspended particulates outdoors was strongly dependent upon traffic factors and penetrated structures only marginally better than the parent particulate;

(5) soiling index measurements indicate low soiling potential generally, with 80 to 90 percent of outdoor levels appearing indoors, except at one public building in winter when indoor concentration drop to 50 percent of outdoors;

(6) the use of a polyurethane foam prefilter to remove non-respirable suspended particulates proved unreliable and was abandoned after the summer program;

(7) carbon monoxide readily penetrates all the structures and anomalies appear readily relatable to source and ventilation variables and, in particular its concentration may be altered by properly phased adjustments in external ventilation;

(8) from carbon monoxide measurements there appears to be little detectable influence of a submerged roadway upon an air-rights structure, other than through its contribution to general pollutant concentration outdoors, or of an underlying parking garage upon an air conditioned building above;

(9) natural ventilation rates in the selected residences, under closed conditions, were almost identical (ventilation time constant - 90 minutes in late summer, about 60 minutes in late fall and winter) despite differences in style and construction;

(10) generally, from 50 to 100 percent of sulfur dioxide outside penetrated the structures when it existed in quantities measurable by the equipment, except at one residence where penetration dropped by a factor of two in winter and additionally by a factor of four at night; and

(11) an overall survey of the ratios of inside to outside concentration indicates that particulates least readily penetrate structures but that specific components penetrate more readily or are re-suspended inside, that sulfur dioxide suffers some loss during penetration, and that carbon monoxide is least affected by penetration and may be enhanced under certain circumstances.

3.0 DESCRIPTION OF SAMPLING PROGRAM

3.1 Sampling Plan

3.1.1 General Description

The principal objectives of this program are:

(1) to obtain data on the quantitative relationships of indoor to ambient outdoor air pollutant concentrations, and

(2) to evaluate various parameters that may affect these relationships.

Three pairs of buildings were selected in and around Hartford, Connecticut, for combinations of characteristics which are described in 3.3.1. Each pair of buildings was sampled simultaneously over a two-week period during the summer, fall and winter seasons. The four classes of pollutants described below were sampled at each structure at four sampling points as follows:

(1) Far Outside — this sampling point is located at a distance from and at a position with respect to the building under study that will represent the total building's exposure to outdoor ambient concentrations of pollutants;

(2) Near Outside — this sampling point is located immediately adjacent to the outside of a window separating the indoor from the outdoor environment and is intended to show the exposure of a typical building opening to outdoor pollutant concentrations;

(3) Near Inside — this sampling point is immediately indoor of the point mentioned in (2) above, and is intended to show the relative quantities of outdoor pollutants entering the structure and the gradient of indoor pollutants between remote indoor locations and a point adjacent to a window; and

(4) Far Inside — this point is located within the structure to show typical levels of pollutants from outdoor or generated indoors to which the occupants are exposed. As noted above, the gradient between this point and the near indoor point will be of special interest.

3.1.2 Pollutants to be Measured

Four different types of pollutants were monitored, each of which is recognized as a component of urban atmospheres, each of which is expected to behave differently in penetrating structures, and each of which may be generated inside the structure.

(1) Total and Respirable Suspended Particulate Matter — Suspended particulate matter in the outdoor atmosphere is expected to penetrate interior spaces. In addition, this type of pollutant is expected to be generated indoors by a wide variety of processes.

A special 4-inch filter was developed by TRC for the collection of total and respirable particulate matter on Type A glass fiber filters. At each of the four sampling points, a total of four filters were located, two of which were fitted with polyurethane pre-filters to provide a sample of respirable particulate matter in accordance with the method of Roesler[1] and two were exposed in the normal manner, to provide a measurement of total suspended particulate matter. One of each type of filter was exposed for 12 hours after which the other pair was exposed for the following 12 hour period. Total and respirable particulate matter concentrations were based on the weight accumulated on the filter papers during the 12-hour exposure periods (approximately 100 cu. m. of air is sampled in 12 hours).

After the summer program the polyurethane filters were abandoned as both TRC and NAPCA had experienced anomalous results. For the fall and winter programs the two parallel filters were operated simultaneously with no particle-size discrimination. Additionally, two particle-sizing "fractionating" samplers were operated for three days (daytime only) at indoor and outdoor positions at each of the six structures in turn.

In addition to the gravimetric determination of particulate concentration and particle size spectrum in the atmosphere, both benzene soluble material and inorganic lead were extracted from selected collections and quantitatively determined.

(2) Soiling Particulate Matter — This type of pollutant present in indoor air penetrates into houses and other structures and is also generated by indoor activities such as smoking, cooking, etc.

---

[1] Roesler, J.R., 1966: Application of Polyurethane Foam Filters for Respirable Dust Separation, Journal of the Air Pollution Control Association, 16:30.

Gelman tape samplers operating in the sampling trailers (one for each of the four sampling points) were used to determine the concentrations of soiling particulate matter based on light transmission through the exposed areas of the filter tapes. Two-hour sequential sampling periods were used.

(3) Carbon Monoxide — This pollutant is unreactive and that which is present in outside atmospheres is likely to penetrate structures freely along with air infiltration (deliberate or otherwise). Further, it can be generated inside structures by the combustion of cooking and heating fuels and smoking.

An Intertech Infra-2 non-dispersive infrared spectrophotometer was used for this measurement. Five-minute samples from the four sampling points were directed sequentially to this analyzer as well as to the SO_2 analyzer by a timer-controlled solenoid valve system to be described later.

(4) Sulfur Dioxide — This pollutant gas is of considerable interest because of its effect on health. It is known to be present in significant concentrations in the outdoor urban atmosphere. However, it is reactive and other workers believe that it does not penetrate structures quantitatively. Indoor generation would probably be limited to faulty heating systems burning oil or coal.

A Sign-X Model 604-B conductimetric SO_2 analyzer was used in this study. As pointed out above, the four sampling points were sampled sequentially on a 5-minute basis.

3.1.3 Sampling Schedule

The plan called for sampling at each pair of buildings over a nominal two-week period, which would include at least one week-end. The actual sampling periods for the three pairs of buildings were:

PUBLIC BUILDINGS:	Summer	Fall	Winter
Hartford Public Library	7/21-7/8	10/9-10/23	1/12-1/26
Hartford City Hall			
OFFICE BUILDINGS:			
100 Constitution Plaza	8/21-9/2	10/31-11/14	1/30-2/13
250 Constitution Plaza	8/21-9/3		
PRIVATE HOMES:			
25 Blinn St. E. Htfd.	9/10-9/29	11/19-12/3	2/26-3/12
60 Carroll Rd. E Htfd.	9/15-9/29		

3.2 Instrumentation

The measurement instrumentation is described in detail in this section.

3.2.1 Measurement Concept

The requirements, as laid down in the sampling plan, called for simultaneous comparative measurements, at pairs of selected business and residential sites. Air quality parameters to be measured for comparison at four points (far outside, near outside, near inside, and far inside) at each site were:

CONCENTRATION OF CARBON MONOXIDE CONCENTRATION OF SULFUR DIOXIDE]	5-min. samples
SOILING INDEX (paper tape sampler)]	2-hr. samples
TOTAL PARTICULATE MASS CONCENTRATION RESPIRABLE PARTICULATE MASS CONCENTRATION]	12-hr. samples

The nature of the sampling plan dictated the use of portable equipment for rapid transport between site-pairs and the distance between the sites in each pair dictated the need for at least two instrumentation packages. The constraints imposed by the nature of the sites dealt with esthetics and potential nuisance to the public and residents. In principle, we felt that full-size instrument trailers and noisy equipment would not be acceptable to those whose cooperation would be solicited. Particularly, we were sure that noisy air samplers, such as the standard HiVol sampler, would not be acceptable when placed inside buildings or near residences. Additionally, a high rate of sample flow taken from inside a residence would interfere by cleaning the air if discharged back into the residence, or by modifying the ventilation rate if discharged outside. We felt constrained from placing any active machinery inside a building, even to excluding flow control solenoids. Equipment placed outside would need protection, some environment control, and noise generated would have to be reduced to a level tolerable in residential areas at night.

With these constraints in mind, and with the objective of creating a flexible monitoring package with the maximum usage of equipment in common, we took the following conceptual path:

——develop two packages, one for each site of a site-pair, and contain in each all of the instruments required;

——make maximum use in common of units such as pumps, analyzers, and recorders, and connect these through valves and tubes to the four sample points at the site. In particular, draw air for particulate samples through eight filter heads and equal length hoses to a central vacuum pump. Use CO and SO_2 analyzers drawing from a common manifold connected at 5-minute intervals in rotation to individual and scavenged lines to the sample points. Record both analyzer outputs on a single multi-trace recorder;

—coordinate the operation through a central control unit in each package;

—house equipment for each package in a small low-profile trailer, provide forced air ventilation for cooling, and supply mains power from the building under test or from a pole drop;

—for each sample point, construct a small shelter to contain four filter heads and to terminate their four hoses and a fifth hose for drawing gas and soiling index samples.

3.2.2 Instrumentation Selection and Specifications

For the collection of particulates, TRC designed and procured a holder for a 4" diameter glass fiber filter and for, optionally, a 4" diameter pre-filter of 60 pore, 1/2" thick polyurethane foam sheet. This filter head was designed with a positive O-ring air seal and constructed (extruded) of black ABS plastic. A double layer stainless steel screen supports the glass fiber filter. Nominal air flow is 5 cfm. The Gast #4565 vacuum pump was selected to draw flows from eight lines simultaneously. Its open-flow rating of 50 cfm reduced to 40 cfm, or 5 cfm per line, at expected line vacuum.

The Skinner V-52 DB 3007 solenoid operated valve was selected to switch each filter line every 12 hours. Its 3/8" orifice passes 5 cfm with a head loss of 20 to 25 inches of water. The fifth line from each point passes directly to a paper tape sampler for soiling samples and line purging, and a solenoid-controlled by-pass flow from this line is drawn through a particulate filter into a manifold with further purging from the main pump. Both CO and SO_2 systems draw sample air from the manifold. The Gelman Paper Tape Sampler selected (four in each instrument package) has a nominal line flow of 40 cfh. These samplers have been modified for external initiation of tape advance.

To record concentrations of CO and SO_2, TRC selected the Beckman (Republic) Model 2550 4-inch, 3-pen electronic strip chart recorder. Sensitivity is one volt full scale and chart speed is three inches per hour.

For CO measurements, TRC selected the Intertech URAS-2 Non-dispersive Infrared CO analyzer, and an automatic zero gas standardization and sample flow humidity control system previously developed at TRC. The analyzer was sufficiently small, fast, and sensitive (to 0.3 ppm CO) for the application and its output adequate to drive a recorder channel to full scale at 30 ppm CO. Time to full response of the CO system is adjustable and of the order of 0.5 to 1 minute.

The Sign-X conductimetric SO_2 analyzer was selected for SO_2 measurements. Its small size made it suitable for portable use and its externally shunted open circuit output (an available option) was adequate to drive a recorder channel to a nominal scale of 0-1 ppm SO_2. The analyzer has an external SO_2 scrubber which could be directly controlled from a central timing unit to show periodic "zero" values for SO_2.

TRC decided to fabricate a custom control unit for each package. The timing function was based on a line-driven pulsing switch whose output would be counted by a series of electromechanical stepping switches. The stepping switches would control the various functions directly, or through relays. This comparatively old and unsophisticated technology was selected as an approach insensitive to momentary power outages. Additionally, to avoid returning all equipment to the line simultaneously in the event of a power interruption, and to prevent rapid on-off operation of the main pump, a built-in delay was planned for the pump motor.

Cooling ventilation for the package was computed at 1000 cfm for a temperature rise of 10°F. A Dayton direct-drive double inlet blower capable of delivering 1200 cfm was specified.

Initial package design indicated a space requirement of approximately 4' x 8' x 2' high. We were unable to find a ready source of prefabricated trailers, with hinged tops, to similar dimensions, so undertook the fabrication of custom boxes to fit commercially available trailer chassis. The Mastercraft Model UT-1500 trailer kit was specified. Salient factors in box design were convenience of operation and maintenance and the suppression of internally generated noise. To this end, the design called for an acoustical absorbent lining for the box and an entrance air plenum constructed of absorbent materials.

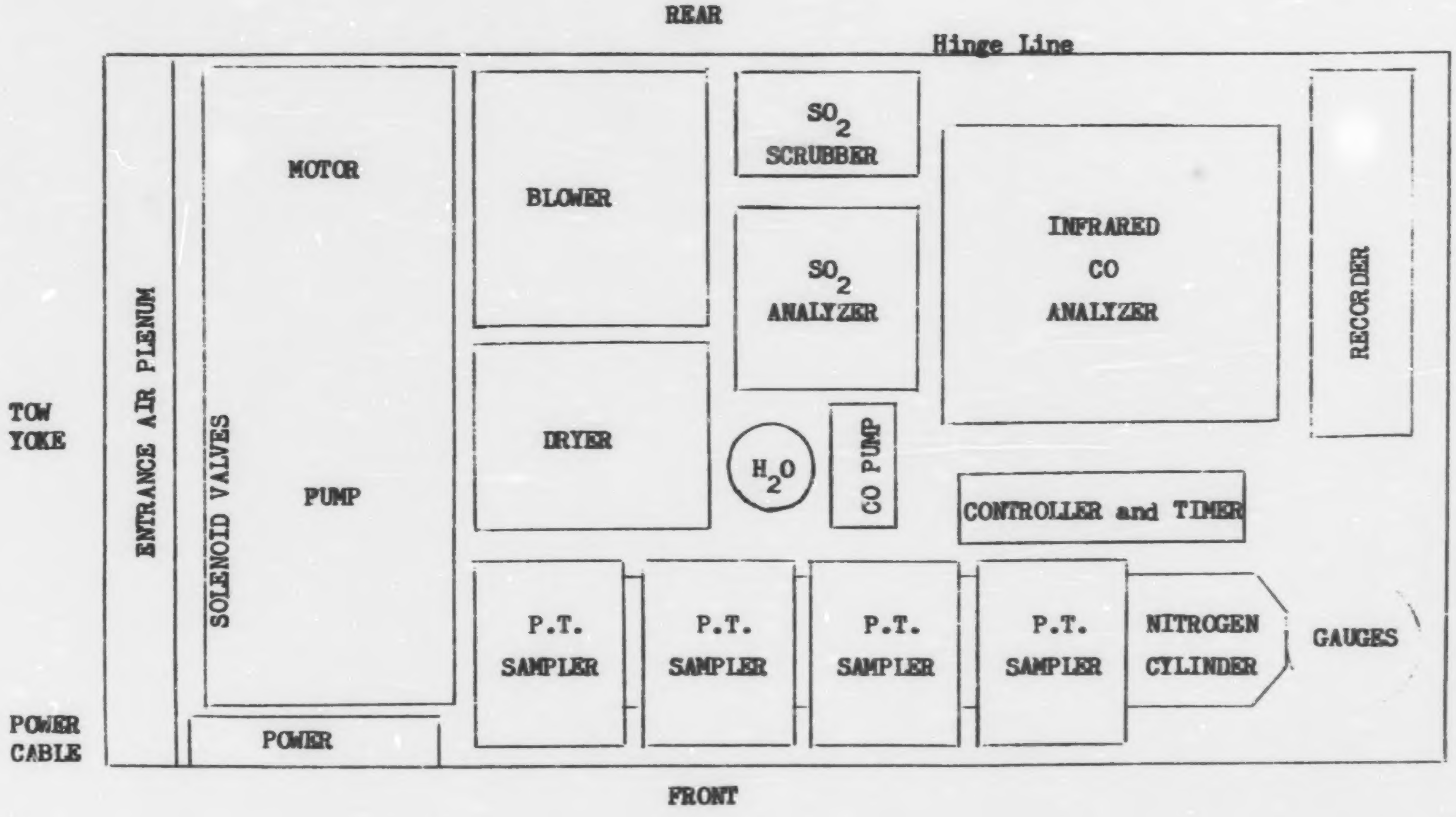
3.2.3 Description of Package and Components

Figure 3-1 is a sketch in plan of the package layout, and Figure 3-2 is a similar photograph to show the arrangement. From left to right are:

——ventilating air entrance plenum -- air enters through a grill and filter in the sloping under-surface to the rear of the box and passes from the plenum through holes in the inner partition. The entrance air cools electrical gear and passes on to the main sources of heat, the pump, motor and paper-tape samplers.

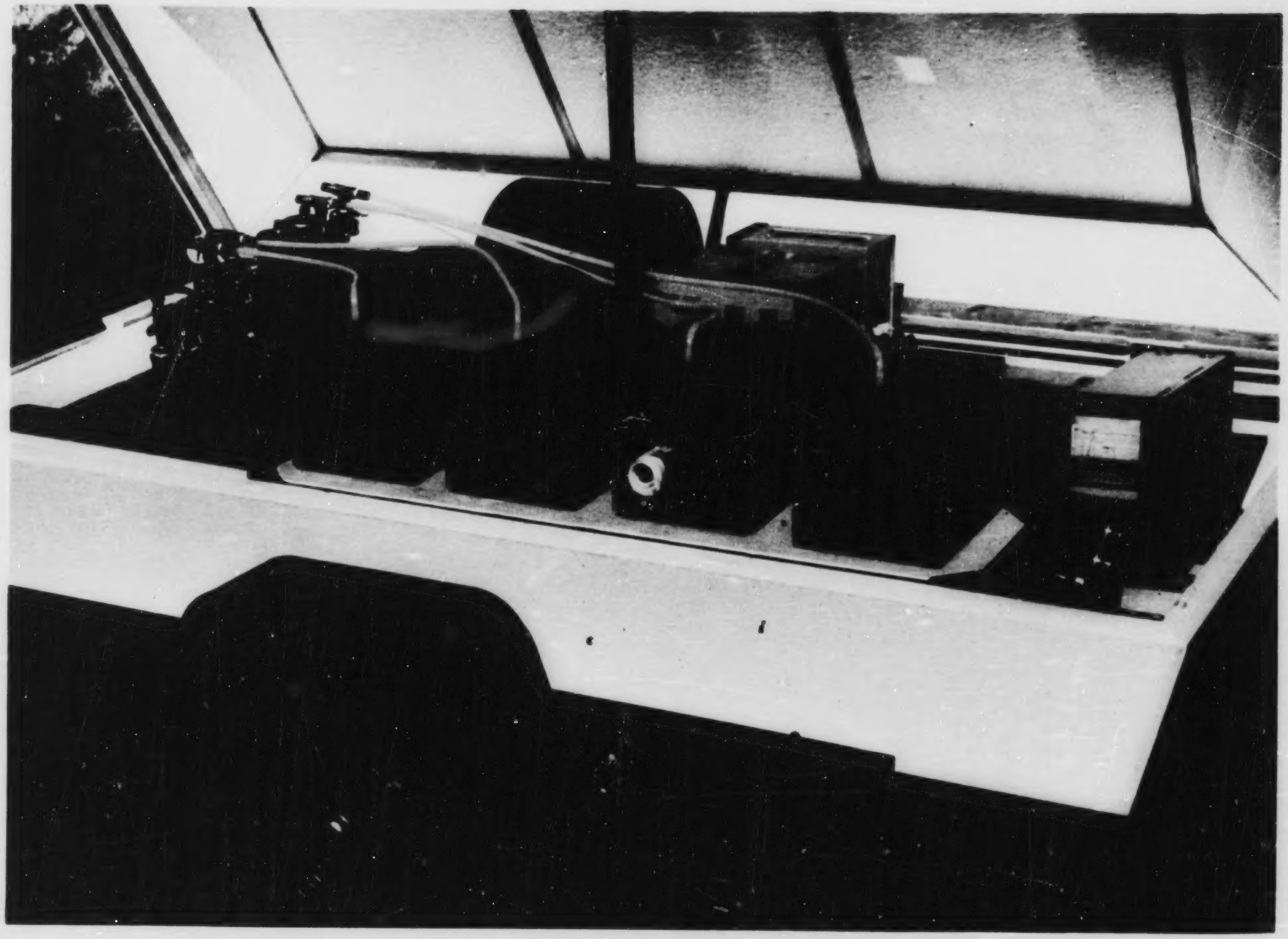
——electrical services -- the larger box is an 8 circuit entrance box for a 40 amp, 230 volt service. Power enters through a 20-foot 4-wire trailer court plug and cable. Six 15-amp services are brought to a strip of grounded outlets on the top of the box, and a 230 volt, 30 amp circuit passes to a magnetic motor-control box to the left and on to the pump motor.

——the main vacuum pump -- just beyond the service box, and attached to the pump is the complex arrangement of flow control solenoids, manifolds, and filters. A 3 hp, 230 volt single-phase motor direct-drives the pump at 1750 rpm. The pump exhaust is directed through a silencing filter bottle towards the front (later


REAR
Hinge Line
TOW
YOKE
ENTRANCE AIR PLENUM
SOLENOID VALVES
MOTOR
PUMP
POWER
POWER
CABLE
BLOWER
DRYER
SO_2
SCRUBBER
SO_2
ANALYZER
H_2O
CO PUMP
INFRARED
CO
ANALYZER
CONTROLLER and TIMER
RECORDER
P.T.
SAMPLER
P.T.
SAMPLER
P.T.
SAMPLER
P.T.
SAMPLER
NITROGEN
CYLINDER
GAUGES
FRONT

PLOT PLAN OF PACKAGE LAYOUT

FIGURE 3-1

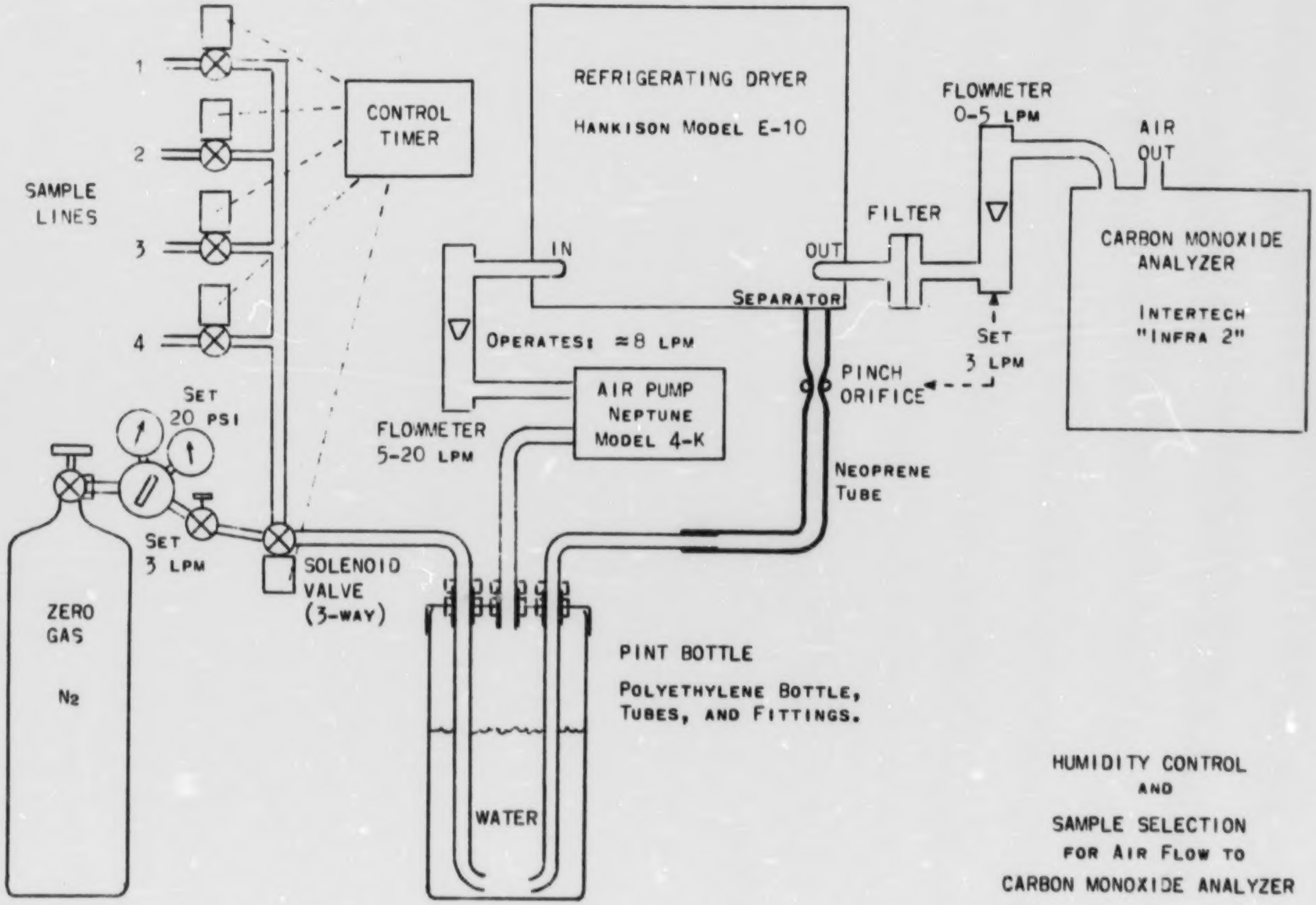


The Travelers Research Corporation Portable Indoor/Outdoor Sampling System changed to two bottles in series directed towards the rear). The pump, motor and plumbing are mounted rigidly together on a platform attached to the trailer box through low-frequency elastomer mounts. The flow control solenoid valves plug into two electrical distribution strips attached to the platform and powered from the central control unit. All plumbing exposed to SO_2 sample gas is stainless steel or polyethlene plastic.

——the blower for air ventilation is placed just to the right of the main motor. The major portion of cooling air enters it from the pump/motor area, where most of the heat is generated. The remainder comes from the paper tape and instrument area, to the right. The blower exhausts downward, through vanes wrapped with acoustic material, to the underside of the box. A house thermostat and motor relay are mounted on the blower to control the package temperature through on/off operation of the blower motor.

——four paper tape soiling samplers sit on a hinged platform along the remainder of the front side. These connect through 3/8 x 1/2 polyethlene tubing to the juncture tees on the pump assembly.

——the nitrogen pressure tank under the hinged platform, the refrigerant dryer just in front of the blower, a pump and water bottle to the right of the dryer, and the CO analyzer to the rear, are portions of the CO measurement system. Figure 3-3 is a schematic of this system, as developed at TRC for the introduction of calibration zero gas and the humidity control of the gas flow into the analyzer. The system uses a pump-driven recirculating flow loop


1
2
3
4
SAMPLE LINES
CONTROL TIMER
SET 20 PSI
SET 3 LPM
SOLENOID VALVE (3-WAY)
ZERO GAS
N_2
REFRIGERATING DRYER
HANKISON MODEL E-10
IN
OUT
SEPARATOR
OPERATES: ≈8 LPM
FLOWMETER 5-20 LPM
AIR PUMP NEPTUNE MODEL 4-K
WATER
PINT BOTTLE
POLYETHYLENE BOTTLE, TUBES, AND FITTINGS.
PINCH ORIFICE
NEOPRENE TUBE
FILTER
FLOWMETER 0-5 LPM
SET 3 LPM
AIR OUT
CARBON MONOXIDE ANALYZER
INTERTECH "INFRA 2"

HUMIDITY CONTROL
AND
SAMPLE SELECTION
FOR AIR FLOW TO
CARBON MONOXIDE ANALYZER

FIGURE 3-3

in which the gas is alternately humidified and then dried to a fixed dew point. A portion of the flow is bled from the loop to the analyzer and replaced by fresh sample air or calibration gas. Pressure to drive the external circulation is generated by the head loss across a pinch valve in the return flow line from the dryer/separator to a water bottle. The water bottle both humidifies all air entering the dryer and collects the condensate from the dryer, thus conserving the water supply. The dew point of sample air to the analyzer will be constant somewhere in the range of 40° to 45°F. An additional effect of the water bottle is to control the pneumatic time constant of the system, which is the quotient of the total air volume in the bottle, dryer, and analyzer, and the external flow rate. In this system, with its effective volume of 1/2 to 1 liter and a flow rate of 3 lpm, the pneumatic time constant is 10 to 20 seconds. Thus, we can expect full response within one minute and have chosed this period for zero gas calibration.

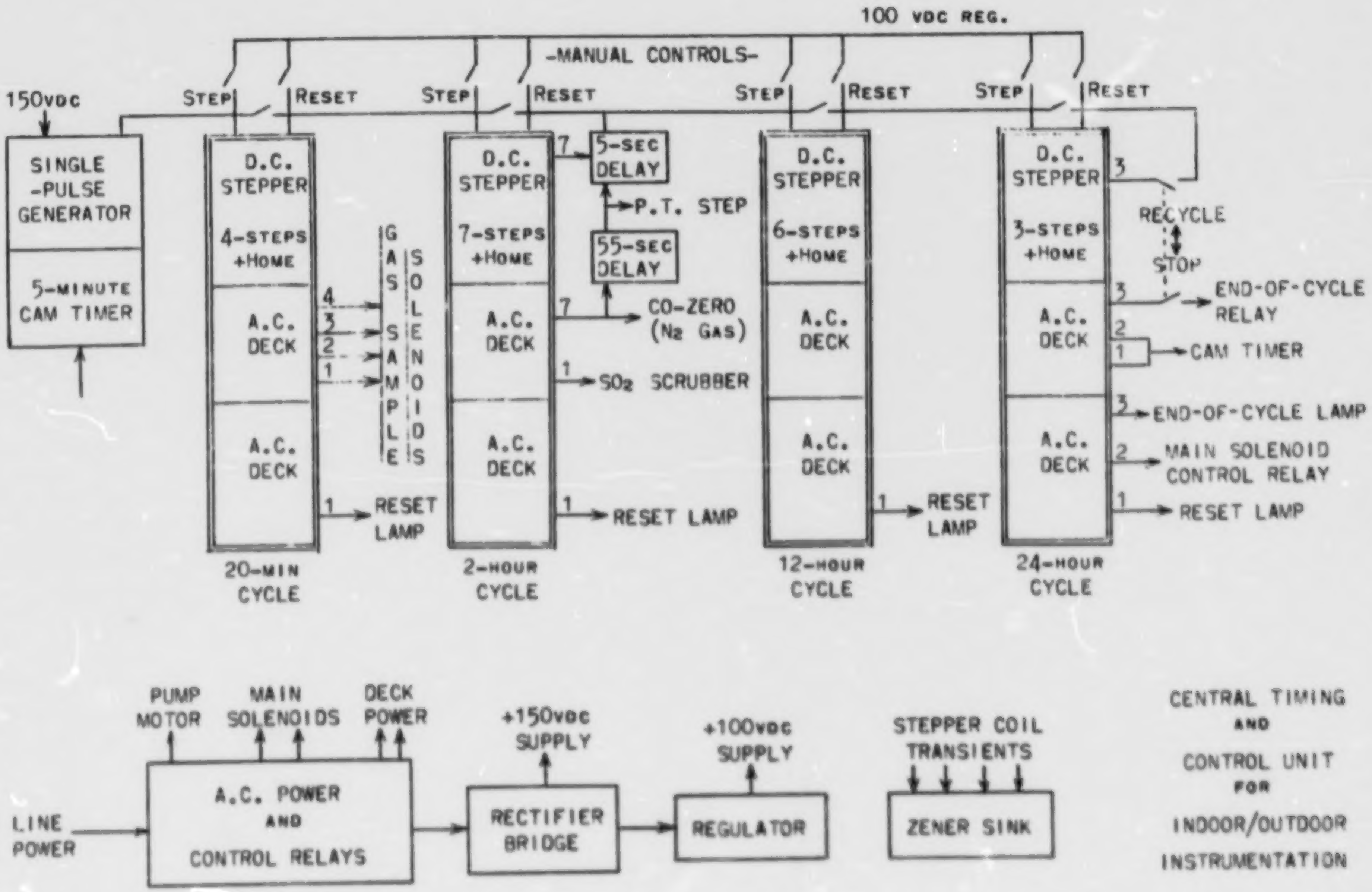
——to the right of the blower are the SO_2 analyzer and scrubber, mounted on an elevated platform which slides forward for maintenance. Connecting tubing throughout is 1/8 x 1/4 polyethylene or small bore teflon where flow equalization is needed.

——at the rear, to the far right, is the multi-channel recorder, mounted on an elevated platform sloping upwards towards the front. The CO system records in blue, and, from its periodic and identifiable zero-gas record, establishes the time scale of the chart. The time prints on the chart are not meaningful. The SO_2 system records in green and its record is displaced 0.1 inches to the right (to later time). The zero of the CO system is normally set to lie between 10% and 30% of chart scale, and a span commonly used is 15 ppm CO = 50%

of scale width. Initially, the SO_2 record operated positively from zero scale. Unfortunately, this led to frequent overwriting of the two records, with attendent difficulties in analysis. This was later eliminated to a large degree by operating the SO_2 record negatively from the full scale point. Span for the SO_2 record is commonly set such that the analyzer calibration resistance lies at about 90% of scale. This is equibalent to a full scale of about 0.8 ppm SO_2.

——the central control and timing unit completes the instrumentation in the trailer. It is located just behind the nitrogen cylinder and has its control panel facing to the right. The design follows an old technique by using stepping switches to count a basic five-minute timing pulse, and thereby generate a 24-hour sequence of control actions. The first switch steps each 5 minutes for 20 minutes, and then automatically resets and steps the second switch. Similarly, the second switch steps each 20 minutes for 2 hours, but does not immediately reset. Instead, it initiates two delay times, in sequence, to obtain a one-minute total delay before reset. This action sets the duration needed (1 minute) for the introduction of zero gas to the CO system and the short pulse (5 seconds) required to trigger the advance of the paper tape units. The delay does not affect the basic timing cycle. Upon reset, the second switch steps the third, at these two-hour intervals, for 12 hours. The third switch resets at 12 hour intervals to step the fourth. The fourth can be programmed to either reset at 24 hours to repeat the cycle indefinitely, or to terminate operations by interrupting the timer and selected power loads.

——the four filter heads at each sample point were mounted in a square shelter box with a hinged peaked top (roof). A center panel


100 VDC REG.
-MANUAL CONTROLS-
150VDC
STEP
RESET
STEP
RESET
STEP
RESET
STEP
RESET
SINGLE -PULSE GENERATOR
5-MINUTE CAM TIMER
D.C. STEPPER
4-STEPS +HOME
A.C. DECK
A.C. DECK
20-MIN CYCLE
4
3
2
1
GAS SAMPLE
SOLENOIDS
1
RESET LAMP
D.C. STEPPER
7-STEPS +HOME
A.C. DECK
A.C. DECK
2-HOUR CYCLE
7
5-SEC DELAY
P.T. STEP
55-SEC DELAY
7
CO-ZERO (N_2 GAS)
1
SO_2 SCRUBBER
1
RESET LAMP
D.C. STEPPER
6-STEPS +HOME
A.C. DECK
A.C. DECK
12-HOUR CYCLE
1
RESET LAMP
D.C. STEPPER
3-STEPS +HOME
A.C. DECK
A.C. DECK
24-HOUR CYCLE
3
RECYCLE
STOP
3
END-OF-CYCLE RELAY
2
1
CAM TIMER
3
END-OF-CYCLE LAMP
2
MAIN SOLENOID CONTROL RELAY
1
RESET LAMP
PUMP MOTOR
MAIN SOLENOIDS
DECK POWER
LINE POWER
A.C. POWER AND CONTROL RELAYS
+150VDC SUPPLY
RECTIFIER BRIDGE
+100VDC SUPPLY
REGULATOR
STEPPER COIL TRANSIENTS
ZENER SINK

CENTRAL TIMING
AND
CONTROL UNIT
FOR
INDOOR/OUTDOOR
INSTRUMENTATION

FIGURE 3-4

divided the box into two compartments, to avoid drawing air across inactive filters. The flow entrance geometry was arranged to duplicate as best as possible the flow conditions of the standard HiVol sampler. Four 5/8 x 13/16 polyethylene tubes connect the four filter holders to the trailer package and a fifth tube is tied to the support post with its end suspended within the confines of an inverted polyethylene funnel to prevent the entrance of water.

3.2.4 Recording Chart Format

The sequence of records appears on the chart as in the following simulation (Figure 3-5). The SO_2 record is shown inverted for clarity and in accord with a change made in recorder arrangements before the start of fall sampling operations.

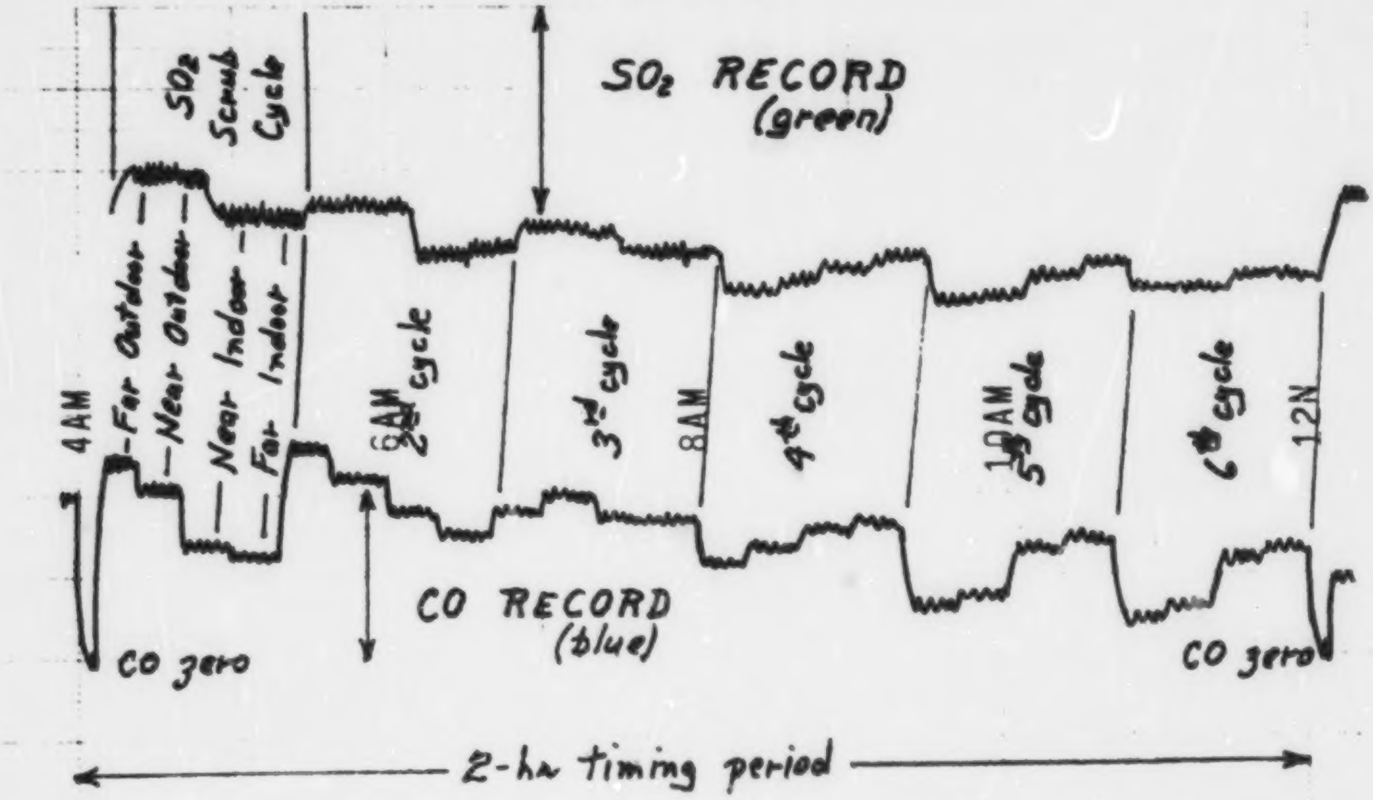


FIGURE 3-5

A basic 2-hour timing period is shown, starting and ending with the 1-minute CO zero record. The two hour period is broken into six twenty-minute cycles during each of which the four locations described as "far outside", "near outside", "near inside", and "far inside", are sequentially measured in that order. During the first 20-minute cycle in each period, the SO_2 scrubber is operated to reveal the CO_2 background at each of the four locations, and no SO_2 information is available during this cycle. It will be noted that the SO_2 record is displaced slightly to the right of the CO record and that the CO zero record actually starts each timing period during a portion of the time normally allocated to the "far outside" measurement.

3.2.5 Maintenance

Routine attention to the instrumentation package is required in the following particular items:

(a) replenish water in reservoir of SO_2 analyzer and adjust analyzer flows — daily. (1 drop of non-ionic detergent in each litre of distilled makeup water)

(b) replenish water in SO_2 scrubber — daily (distilled water)

(c) replenish oil in main pump oilers — every 2 to 3 days

(d) maintain water level in CO humidifier — check daily

(e) check recorder chart and ink operation — daily

(f) check general operation and other supplies

(g) mark time on recorder chart and paper tape records.

The only maintenance item which proved to be marginal over a 30-hour period was the SO_2 scrubber water supply. A redesign of the scrubber increased the margin, improved performance, and eased a refilling problem.

3.2.6 Calibration Techniques and Assigned Accuracies

Measurement accuracy information was developed during the program to the point where we can advance the following statements concerning individual measurement system accuracies.

Suspended particulate measurements: The design flow for each line was 5.0 ± 5% cfm and was based on manufacturer's information on the characteristics of the vacuum pump and upon calculated head losses in the system. Our evidence of the correctness of this design figure is based on measurements of comparative head drop across the throttling solenoid valves and upon side-by-side redundant filter comparisons, both of which indicated that relative flows were within a range of 5 percent. Measurement with a large rotameter showed that flows were uniform and were, after correction for imbalance imposed by the head drop of the rotameter, near 5 cfm. The weighing procedure was accurate to a fraction of a milligram, and the side-by-side comparisons suggest an inherent accuracy of the sampling process of the order of 5 percent of 1 milligram. Weighing accuracies for benzene extracted fractions and of the fractionated particle samples were of the order of 100 to 200 micrograms.

Soiling index measurements: A highly accurate flow measurement was first applied to the paper tape samplers. However, with field experience and further calibration activities, we decided that inherent accuracy did not warrant fine calibration procedures and, instead, assumed that the flow in a properly operating sampler was 37 ± 10% cfh. In addition, we experimentally determined that approximately 14 percent of the potential soiling index was lost in the airstream travel through 100 feet of sampling tubing. This calibration and correction was applied to all soiling index data reported in Volume I and its data supplements.

Carbon Monoxide measurements: The zero reference system described in this report ensured that the error due to unknown zero would almost always lie within 0.3 ppm. We found that the scale factor calibration was very conservative and would change by less than 10 percent over a period in the field. The reference was Scott Research CO calibration gas at 15.1 ppm, which was cross checked with another cylinder of similar gas containing 30 ppm CO. We feel that, in general, the CO data is probably accurate to 5 percent or 0.2 ppm, whichever is greater.

Sulfur Dioxide measurements: Analyzer calibrations were checked at three points (approx. 0.2, 0.4 and 0.6 ppm SO_2) against commercially supplied diffusion tubes. In intercomparison checks and in a calibration against the West-Gaeke procedure, one could claim an accuracy figure of better than 5 percent for the diffusion tube method. In laboratory calibrations of the analyzers, while selected results were very consistent, one could not claim better than 10 percent accuracy in general. In the field, with shifting CO_2 interference and with flow control problems descirbed later, accuracies are probably of the order of 0.015 ppm or 20 percent, and in some fault conditions errors would be greater. While some of the errors would be balanced in comparison measurements, the variable concentrations of interferring CO_2 would continue to degrade the data.

3.2.7 Performance

As is commonly anticipated with new instruments and complex packages, we experienced a few malfunctions which should be described.

The control unit suffered two serious malfunctions. First, the timing was affected by unreliable stepping, which was cured by the double procedure of introducing a basic pulse circuit which could not produce multiple pulses, and an improved power supply with better regulation. Then the better power supply proved to be susceptable to stepping transients, resulting occasionally in its self-destruction. The power supply design was improved and better components procured to prevent a recurrence.

A mystifying malfunction of the ventilation blower occurred several times. The package would be found in an overheated condition and the blower not operating. However, the blower would perform satisfactorily a few minutes after the trailer top was opened. After a number of false starts towards a cure, we discovered that the blower motor had a capsule thermal overload switch hidden in its windings. Apparently, when interrupted by the thermostat after a lengthly running period, the stored heat in the motor would open the overload switch and it would have no chance to close before the rising temperature in the trailer would hold it open and prevent further operation of the blower. The cure was simply to remove the overload switch as we would rather risk a $15 motor than an overtemperature condition.

During the second period in the field, one main pump seized and the other was impaired by the failure of their lubrication systems. This condition had arisen from the addition of a second oil-trap/silencer to the exhaust train to further control oil mist and noise. Both the pump manufacturer and the field representative advised that the second trap would not affect oiling but tests we performed after the fact showed that the increased back pressure was just sufficient to reverse the flow of oil to the bearings, and thereby deprive the vanes of lubrication. This condition would only happen when the pump is operated at the low vacuums used in this package and the condition was beyond the experience of the manufacturer. To avoid the implications of alternative oiling techniques, we simply added tubing from the exhaust manifold to the oil resevoirs to pressure the oil supply and thereby ensure the unidirectional flow of lubricating oil. New vanes and rear bearings were installed in the pumps.

The arrangement of the flows for the gas analyzers has not been fully satisfactory and has led to additional data loss under certain fault conditions. The selected sample flow is admitted to the manifold through the corresponding solenoid-controlled valve. Both analyzers draw together from the manifold. To ensure purging, we have a 1/2 cfm bleed from each end of the manifold to the main pump lines. As a further complication, we found it necessary to make several moves to prevent one analyzer pump from backdrawing liquid from the second analyzer in certain fault situations. One move was to place a poppet-type vacuum relief valve on the manifold. This, however, led to the loss of gas samples whenever a momentary power outage allowed the selected solenoid valve to close, increasing the vacuum in the manifold through the bleeds to the main pump and unnecessarily operating the relief valve.

3.2.8 Program Changes

At the start of the measurement program, the proposed procedure for changing particulate filters daily was found to be inadequate. As an alternative procedure, the filters were then changed in blocks, one group before the 7 p.m. changeover and the other group afterwards. With this change, there was no longer the need to terminate sampling at 7 p.m., with a subsequent manual restart. Instead, we rearranged the control unit to provide the option of automatic recycle at 7 p.m., or of cycle termination. In this way, blocks of filters could be changed at any time during their inactive 12-hour periods.

A reassessment of requirements at the end of the summer season led to two changes. Further NAPCA experience with polyurethane prefilters had not been entirely satisfactory, and preliminary TRC results confirmed that this approach to the measurement of respirable particulates was unreliable. It was also noted that for analyses beyond daily mass weights, it would be necessary to combine filters into week-long groups of seven. At this point, NAPCA and TRC agreed to eliminate the prefilters, but to continue operating two filters in parallel, and to operate individual filters for a week (either days or nights). These decisions required no change in instrumentation as the control unit was now capable of automatic recycle. To replace the discontinued respirable particulate measurements, NAPCA provided two modified Andersen sampling systems for simultaneous indoor/outdoor particle size measurements, and these were scheduled for 3-day, 7 a.m. to 7 p.m. collections at each site, for each of the remaining two seasons.

The program originally called for the measurement of some index of structure permeability at the two private homes. The first plan was to measure permeability directly through the air flow resulting from the application of a small overpressure to the structure. During the summer program, we decided that this approach was less practical than a tracer gas technique for measuring ventilation rate, in light of the fact that we were already equipped and in place to measure CO concentrations. With this thought, and with NAPCA concurrence, we distributed a timed release of pure CO throughout the interior of each structure when we could anticipate no occupancy. Peak measurements did not exceed 100 ppm CO during a short mixing period and these rapidly reduced to the order of 25 ppm for the start of measurements. Concentrations were near background within five hours.

3.2.9 General Comments on Instrumentation

In the course of any project involving the development and use of a relatively novel and sophisticated instrumentation package, there are certain to be features to which more desirable alternative are now clear. One basic change in approach should be to cooling, as much from the viewpoint of acoustic isolation as from constancy of temperature. It proved difficult to properly attenuate sound transmission through the intake and exhaust grills required for the large amounts of ventilation air in a blower-cooled package.

In an alternative approach, a small air conditioner package could be installed with the compressor and cooling coils on the inside and a separate fan and heat exchange coils on the outside. The only air communication would be the sampling flows into the trailer box and a small, long, acoustically lined duct for outflow of trailer air and main pump exhaust. The lesser advantages are more constant temperature and a small positive internal pressure to prevent leakage flows into the trailer. A disadvantage to a cooled system would be the potential loss of SO_2 in high humidities. This would have to be investigated and SO_2 lines in the trailer might have to be heated.

The Sign-X conductimetric analyzer was chosen for the package because of its compactness, response and immediate availability. Our experience suggests that, in sampled data systems, there are too many problems inherent in a conductimetric analyzer. In addition, maintenance requirements and uncertainties in fluid flow control in the Sign-X leads one to consider an alternative instrument operating on a physical principle, such as the flame photometric detector for total sulfur which has become available more recently.

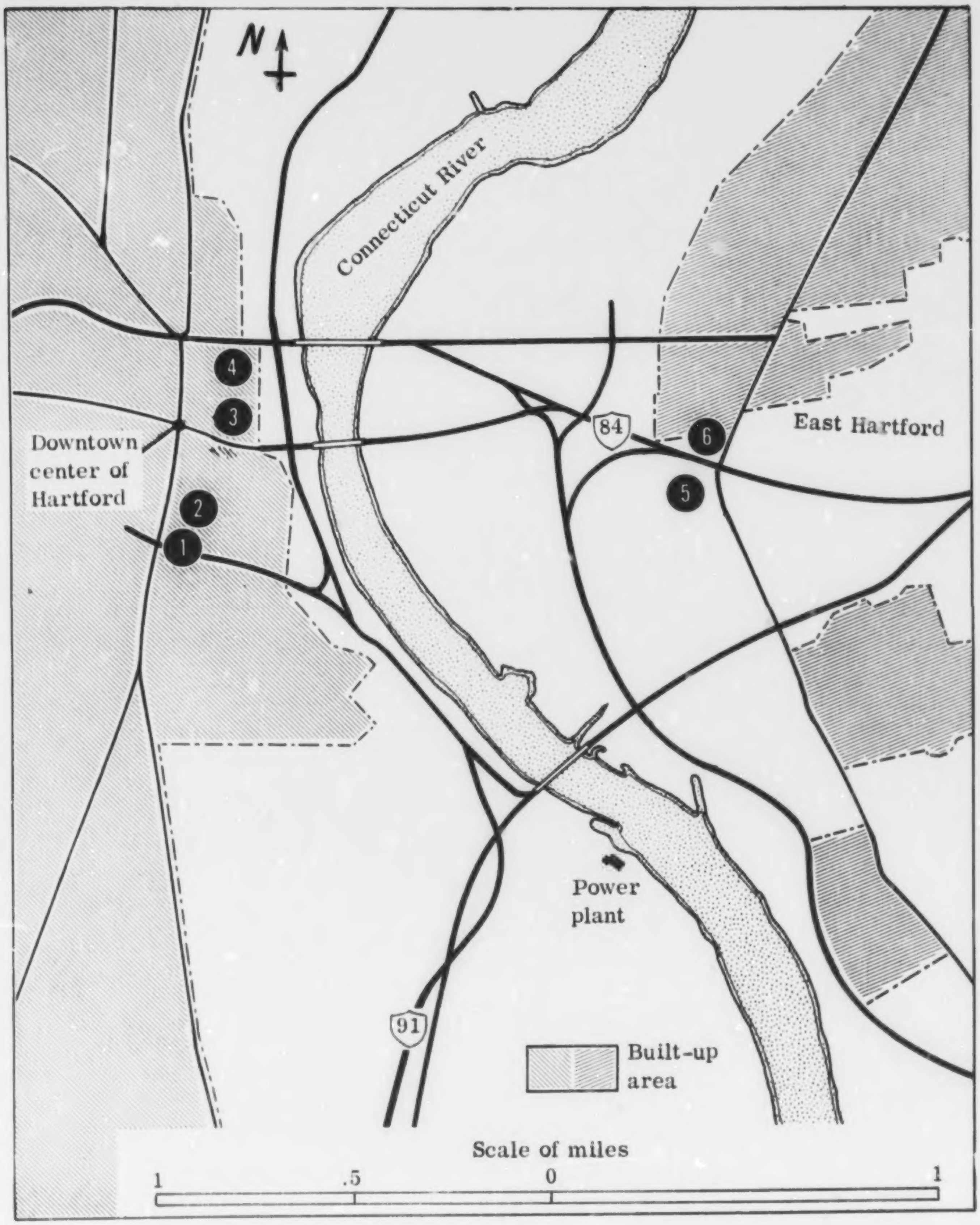
An interesting fault condition occurs in the system, more probable during maintenance operations, if the four sampling solenoid valves are all closed. If the SO_2 pump is operating, it will backflow water from the CO humidification system through the plumbing and if the SO_2 pump is off, water flows similarly from the SO_2 reservoir and scrubber into the plumbing. We now feel that a binary "tree" valve arrangement would be better, despite the more complicated switching arrangement. In this way, the manifold would always be vented to a sampling line. This fault has been further complicated by an orifice arrangement to bleed a scavenging flow of air from each end of the manifold into the main pump. This additional flow worsens the fault condition and led us to install a safety vent which, in turn, gave further problems in leakage and unnecessary operation during momentary power failures. A more critical inspection suggests that the manifold, being scavenged from each end by the flow into the two analyzers, does not require bleed flows into the main pump for this purpose. The alteration of the solenoid-valve arrangement and the closing of the bleed flows then eliminates any requirement for a safety vent and it could be removed. This combination of modifications would enhance operational reliability.

3.3 Structures Sampled

Three basic types of structures were used for the study: public buildings, office buildings, and private homes. A pair of buildings of each type was sampled simultaneously. Structures in each pair were essentially similar, except for one design feature which might affect the exposure to and the penetration of certain pollutants. The locations of the six structures are shown in Figure 3-6.

3.3.1 Public Buildings

The pair of public buildings used in the study are located approximately 1/2 mile south of the main downtown area. One of the buildings, The Hartford Public Library (#1), was built as an air-rights structure over a four-lane highway connector to I-91. The second building (#2), is the Hartford City Hall, which is located to the north of the Library and is separated from it by a heavily travelled street. Neither building is air conditioned, and both are of masonry construction. During the summer season, windows in both buildings


N
Connecticut River
Downtown center of Hartford
East Hartford
84
91
Power plant
1
2
3
4
5
6
Built-up area
Scale of miles
1
.5
0
1

Map showing study area and approximate locations of test buildings.

FIGURE 3-6

were frequently open.

The sample points were located at the east side of both buildings. Indoor samples in the Library were taken from the main reading room and at the City Hall from the City Clerk's office. It should be noted that, while sampling the east side of these buildings, the City Hall has active entrances on all faces of the building and the Library has its only active entrance facing west. Thus, with windows closed in the winter, the Library may respond differently and be affected more inside by traffic on Main Street immediately to the west than during the summer and fall when rows of windows facing north and east are commonly open. Table 3-1 describes the location of the sample points in more detail.

3.3.2 Office Building

The pair of office buildings are located in Constitution Plaza, an urban renewal area in the center of Hartford. One of the buildings (#4) is a six story structure at 250 Constitution Plaza, built directly over a five level partially underground parking garage and connected to the garage by stairwells and elevator shafts. The other office building (#3) is a 16 story structure at 100 Constitution Plaza, not built over the parking garage. Both buildings are air-conditioned and therefore have no open windows. To prevent infiltration of air from the parking garage, an attempt is made to pressurize the smaller office building by returning or recirculating significantly less air than the air conditioning system provides to the building.

PUBLIC LIBRARY	located 20' east of the structure, 8' above ground level & adjacent to submerged roadway.	just outside window on east wall of library over roof of single story service area above roadway.	inside same window on east wall and in main reading room.	in main reading room at north end near wall 6' above floor and 20' from window.
CITY HALL	approx. 15' east of building and 15' above adjacent street level.	outside second floor window on east wall, approx. 25' above street level.	inside same window which is City Clerk's office, occupied by about 12 people.	in Clerk's office, on south wall, 6' from floor and 20' from window.
100 CONSTITUTION PLAZA	at northeast corner of building, 15' north and 10' above plaza.	outside second floor glass wall on east side and 15' above plaza level.	inside glass wall in a second floor unoccupied office.	in second floor office far wall, about 10' from window and 6' above floor.
250 CONSTITUTION PLAZA	at east side of building one level above plaza and 10' from building.	outside third floor window on east side and 20' above plaza level.	inside a secretarial office area next to window.	approx. 10' from window in office area, 6' above floor
BLINN STREET	10' from east side of house, 6' above ground level.	outside dining room window on east side of house and 6' above ground level.	inside dining room window and 4' above floor level.	along dining room wall 10' from window and 6' above floor.
CARROLL STREET	at rear of house, approx. 25' from northwest corner and 6' above ground level.	outside dining room window on west side of house and 6' above ground level.	inside dining room window and 4' above floor level.	in dining room about 10' from window along wall separating kitchen and dining room.
	FAR OUTSIDE	NEAR OUTSIDE	NEAR INSIDE	FAR INSIDE

TABLE 3-1 DESCRIPTION OF SAMPLING POINTS

Air change time-constant in both buildings is about 10 minutes. In the summer, when cooling is required, only ten percent of circulated air is fresh. In fall and winter the proportion of fresh air may be as high as 100 percent, lowering to the order of 50 percent with cold winter temperatures. All circulating air passes through filters whose efficiency at 100 CP is about 40 percent at 2 microns, 79 percent at 5 microns, 91 percent at 10 microns. At 250 CP three of these filters are used in series. The air intake at 100 CP is at the north side on the Plaza level, at some distance from the nearest street. It is very close to the far outside sample point. The air intake at 250 CP is on the east side of the roof, some seven floors above street level. The systems at 100 CP are operated from 6:00 a.m. to 6:00 p.m., six days a week. At 250 CP the hours are 5:30 a.m. to 9:00 p.m.

Sample points were located on the east side of both buildings, one to two floors above the Plaza level. Inside samples were taken in typical office areas. The sample points are described in more detail in Table 3-1.

3.3.3 Private Homes

Both homes (5 and 6) are located in East Hartford, in the midst of a freeway interchange network. A 200 megawatt power plant burning 2% sulfur fuel oil is located approximately 1 mile south of the homes. One home (#6) is located at 60 Carroll Road, to the north of Interstate Highway I-84, and the other (#5) at 25 Blinn Street, on the opposite side of the same east - west road. With winds from the south, the houses are located at the point of maximum ground-level concentration of SO_2, based on the prevalent meteorological conditions. One of the homes is considerably newer than the other, is fitted with storm windows and appears to have been better maintained than the second house. Neither house is air conditioned, nor do they have gas stoves which are a source of internal carbon monoxide. A significant difference between the two homes is their occupancy. The structure at 25 Blinn Street is a duplex in which we sampled the lower residence. It is occupied by a working couple. The man works from 2:00 p.m. to late evening in a manufacturing industry, the woman from 8:30 a.m. to 5:00 p.m. with Wednesdays and Sundays off. The structure at 60 Carroll Road is a single-family colonial home, occupied by an active teenage family. The mother worked days during the summer and fall operations. No habitual smoking took place in either home.

4.0 FIELD OPERATIONS-Summer, 1969

The two trailers and associated sampling heads and tubing were installed at the first pair of buildings in July. Power connections were installed at the City Hall and Library on the 8th, trailers on the 11th and 13th, tubing and sampling heads during the following week, with instrumentation start-up on the 21st. Filters were changed daily, initially at 1900 hours, but we quickly determined that it was not practical to change these in one operation at 1900 hours, and instead developed the approach of changing filters in two operations. The night filters were changed before 1900 hours, and the filters for the following day were changed after 1900 hours. In this way no time was lost during changing operations, and the control unit was modified to recycle automatically. The sampling program was allowed to run to the 7th of August, a period of 17 days, to compensate for start-up problems. Equipment was returned to the instrumentation laboratory on the 8th for those modifications and adjustments whose need was revealed during this period.

The sampling trailers were hoisted to Plaza level on the 15th of August, for installation at the next pair of buildings, 100 and 250 Constitution Plaza. Final consensus on the best way to insert lines into 100 C.P. was to cut a corner from a window, and this was done on the 19th by the original glass installer. Installation of power, sampling heads, and lines followed through the same week, and operations were started on the 21st. Sequential data was lost for short periods at each location, through control unit power supply failures. One main pump failed on the 2d of September, and the other was deteriorating at such a rate that we decided to foreshorten the sampling period to 12 days, and the trailers were returned to the laboratory on the 4th. The pumps were repaired and modified to avoid a recurrence of the oiling malfunction which preceeded the failures.

Power at the East Hartford homes at 25 Blinn Street and 60 Pitkin Street was installed on the 9th of September, and the trailers and sampling heads on the 10th. The measurement operations started the evening of the 10th, but were interrupted at 60 Pitkin Street the following morning, when the non-resident owner objected to the visual effect upon the property. An alternative location, at 60 Carroll Road was negotiated, and the equipment installed on the 15th. The CO tracer gas measurement of building permeability was applied on the 26th and the trailers were taken out of service on the 29th of September to terminate the summer sampling program.

FIELD OPERATIONS-Fall, 1969

The fall field operations started shortly after the completion of the summer program and ran from October 9, to December 3. The order of operation was as in the summer program, but the periods of operation were more exactly two weeks at each site. With the advice and consent of NAPCA, suspended particulates were collected for a full week on each filter, that is, an individual filter contained the collection for seven consecutive daytime periods or seven consecutive nighttime periods. In another agreed change, the pre-filter arrangements were discarded, but the filter remained active, which led to duplication of each collection. The consistency of mass collections could now be checked and double the mass of material was available for chemical analysis. Two particle-size fractioning samplers supplied by NAPCA were operated as a pair sequentially at the sites, starting November 3 and ending December 5. The order of site locations was the same as the main program but the schedule was late at the start due to delays in receiving and putting the equipment into service. The CO tracer gas measurement of building permeability was applied to the Blinn Street and Carroll Road structures on the third of December.

The operation was much smoother and the equipment operated much better during the fall than during the summer. Some data was lost, particularly SO_2 data at the Library, 250 Constitution Plaza, and Blinn Street, due to problems in the maintenance of uniform sampling flows and the unwarranted operation of the vacuum relief valve. In one unit the SO_2 analyzer water flow was reduced, we found, by carbon particles settling in the reservoir from a previous pump failure and plugging a filter screen. Replacement of the reservoir cured this problem, leaving some losses due to the vacuum relief valve whose malfunction primarily affected only the SO_2 analyzer.

FIELD OPERATIONS-Winter, 1970

The winter field operations running from January 12 to March 12 1970 followed identically the pattern of the fall observations, with the one exception that the fractionating samplers were operated on a more regular schedule. Their three sampling days were spaced in the mid-week portion, first at one - then at the second, of the two week sampling period at each pair of structures. The CO tracer gas measurement of building permeability was again applied to the two residences on the last program day, the 12th of March.

With the exception of a series of instrument and maintenance problems which disabled the SO_2 at the Library for one week, the operation proceeded smoothly despite the winter weather. For the winter operation the air tubes to inside locations were installed in a flexible foam plastic insulating jacket to avoid condensation in sample lines and better arrangements were made to prevent entrance of cold air into homes at tubing and power cable entrance.

At the completion of the field measurement program, the temporary arrangements made at sites for power and other installations were withdrawn, and the sampling equipment returned to the instrumentation laboratory.

5.0 SAMPLING RESULTS

Particulate soiling index, carbon monoxide and sulfur dioxide were sampled and suspended particulates were collected, weighed and selectively assessed for benzene soluble fraction and inorganic lead content. Summaries of the data and comparative analyses are presented in this section, with more detail contained in processed but unanalyzed data in three data supplements to this volume.

The data reported here for the summer program have, in a number of instances, been further processed to take advantage of improved knowledge of instrument calibrations, field operations, and data presentation techniques. Therefore, where results reported here vary from those contained in the earlier summer program report (ref. p. 1) it must be assumed that these results are more reliable and are, in any case, consistent with the remainder of the data in this report.

Two types of averages are reported in data summaries. These are either straight averages of the respective columns (arithmetic average), or are ratios of averages computed in the more basic table. The latter approach is taken in ratio tables to avoid the misleading bias when strongly fluctuating ratios are averaged.

Throughout, the computation of day/night ratios have used data from the 12-hour night period (7 p.m. to 7 a.m.) and the following day period (7 a.m. to 7 p.m.) over the time interval specified. Where data tables span more than one calendar day, and only one date is given, it applied to the beginning of the period of observation. This occurs in many of the computer generated tables in the data supplements.

5.1 Suspended Particulates

Both respirable and total suspended particulates were measured during the summer season. The summary of the two week average mass concentration is presented in Table 5-1. Further analyses of this data are presented as far inside/far outside ratios in Table 5-2, as day/night ratios in Table 5-3, 5-4 and 5-5. The measurement of the respirable particulate fraction by the method of Roesler (ref. p. 7), while now considered by both NAPCA and TRC to be unreliable with the recommended materials, and particulate collections on individual 12-hour filters, leads to detailed presentations in Figures 5-1 to 5-6. These figures present all the suspended particulate weight data for the summer season. The legend shows the presentation technique, the handling of those occasional circumstances where the respirable fraction appears to exceed the total, and the sequence from outside to inside, day to night, for each day through the sampling period.

The discontinuance of the respirable sample and the accumulation of week-long collections upon single filters in the fall season leads to a different presentation. Table 5-6 is similar to Table 5-1 in listing the mass concentrations of suspended particulate. Instead of the two listings of respirable and total, we instead list the total only, for the 2 weekly periods and the average of the two. Each listing represents the mean of a pair of simultaneously collected samples. The absolute value of the individual

TABLE 5-1

SUSPENDED PARTICULATE - SUMMER SEASON AVERAGES $\mu g/m^3$

Sample Point	Library		City Hall		100 Const. Pl.		250 Const. Pl.		Blinn Street		Carroll Road	
	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
Far Outside												
Respirable	71	49	67	49	77	76	90	85	60	48	51	40
Total	132	82	153	78	104	93	124	109	79	65	66	56
Near Outside												
Respirable	52	62	64	49	83	89	85	82	58	51	49	46
Total	98	66	145	76	118	98	115	102	87	65	60	49
Near Inside												
Respirable	47	43	61	48	65	52	57	61	53	48	59	51
Total	70	45	78	52	49	49	57	67	67	51	73	47
Far Inside												
Respirable	45	37	58	43	51	49	56	65	58	45	58	40
Total	66	43	78	49	50	46	56	60	70	56	76	47
PERIOD	July 24 to August 7				August 22 to September 2				Sept. 16 to Sept. 29			

TABLE 5-2
FAR INSIDE/ F R OUTSIDE RATIOS FOR TOTAL SUSPENDED PARTICULATE—SUMMER SEASON

Date	Public Library		City Hall		Date	100 Const. Pl.		250 Const Pl.		Date	Blinn St.		Carroll Rd.	
	Day	Night	Day	Night		Day	Night	Day	Night		Day	Night	Day	Night
24 July '69	0.41	0.50	1.49	0.59	22 Aug '69	0.63	0.37	0.34	0.47	16 Sept '69	0.76	0.84	0.82	0.65
25	0.59	0.56	0.83	0.62	23	0.24	0.28	0.27	0.60	17	0.94	1.47	0.83	0.74
26	0.26	0.42	0.27	0.39	24 Sunday	0.30	0.22	0.34	0.76	18	1.00	0.61	1.33	0.58
27 Sunday	0.30	0.51	0.28	0.56	25	0.48	0.47	0.33	0.23	19	0.74	0.72	1.43	0.68
28	1.21	0.85	0.86	0.79	26	0.83	0.66	0.69	0.67	20	0.87	—	1.32	1.22
29	0.61	0.61	0.65	0.56	27	—	0.60	0.71	0.39	21 Sunday	1.59	0.67	9.10	0.71
30	0.37	0.55	0.41	0.59	28	0.55	0.65	0.40	0.62	22	1.01	0.91	0.95	0.99
31	0.55	0.67	0.52	0.59	29	0.42	0.51	0.33	0.48	23	0.81	0.70	1.02	0.81
1 Aug '69	0.61	—	0.62	1.52	30	0.32	0.60	0.31	0.35	24	0.69	0.89	1.64	0.60
2	0.50	0.31	0.23	0.54	31 Sunday	0.57	0.48	0.60	0.73	25	0.67	0.98	0.77	—
3 Sunday	0.83	0.55	0.63	0.71	1 Sept '69	0.55	0.40	0.58	0.58	26	0.62	0.85	0.85	1.79
4	0.52	—	0.35	0.86	2	0.30	—	0.33	—	27	2.18	0.86	1.11	1.79
5	0.34	0.50	1.04	0.63						28 Sunday	—	1.72	—	1.11
6	0.37	0.54	0.52	0.44						29	—	0.94	1.12	0.81
7	0.83	0.66	0.53	0.76										
Ratio of Average	0.50	0.52	0.51	0.63	Ratio of Average	0.48	0.49	0.45	0.55	Ratio of Average	0.89	0.86	1.15	0.84

TABLE 5-3
DAY/NIGHT RATIOS FOR TOTAL SUSPENDED PARTICULATE—SUMMER SEASON

Date	Public Library				City Hall			
	Far outside	Near outside	Near inside	Far inside	Far outside	Near outside	Near inside	Far inside
24 July '69	1.63	1.28	1.56	1.36	0.76	1.41	1.83	1.93
25	2.05	2.30	2.38	2.18	1.92	2.04	2.40	2.57
26	3.63	2.68	2.35	2.00	4.53	5.25	4.43	3.13
27 Sunday	2.41	1.65	1.10	1.40	3.32	3.23	1.26	1.64
28	1.25	2.11	1.78	1.76	2.74	2.40	2.52	2.97
29	1.37	1.15	1.96	1.37	1.29	1.22	1.02	1.50
30	1.60	1.07	1.57	1.10	2.01	1.90	1.21	1.41
31	0.70	0.66	0.64	0.58	1.14	1.03	0.80	1.00
1 Aug '69	3.37	—	—	—	—	5.32	3.91	4.46
2	2.33	2.86	3.45	3.76	3.00	3.08	1.43	1.28
3 Sunday	1.03	1.25	2.21	1.57	1.34	1.47	0.84	1.20
4	2.14	2.65	5.05	—	2.93	1.91	2.03	1.18
5	2.19	2.18	1.74	1.48	1.09	2.65	1.57	1.81
6	1.22	0.99	1.07	0.84	1.55	1.19	1.20	1.84
7	1.21	0.88	0.68	1.51	0.91	0.85	1.07	0.70
Ratio of Average	1.61	1.48	1.55	1.53	1.96	1.91	1.50	1.59

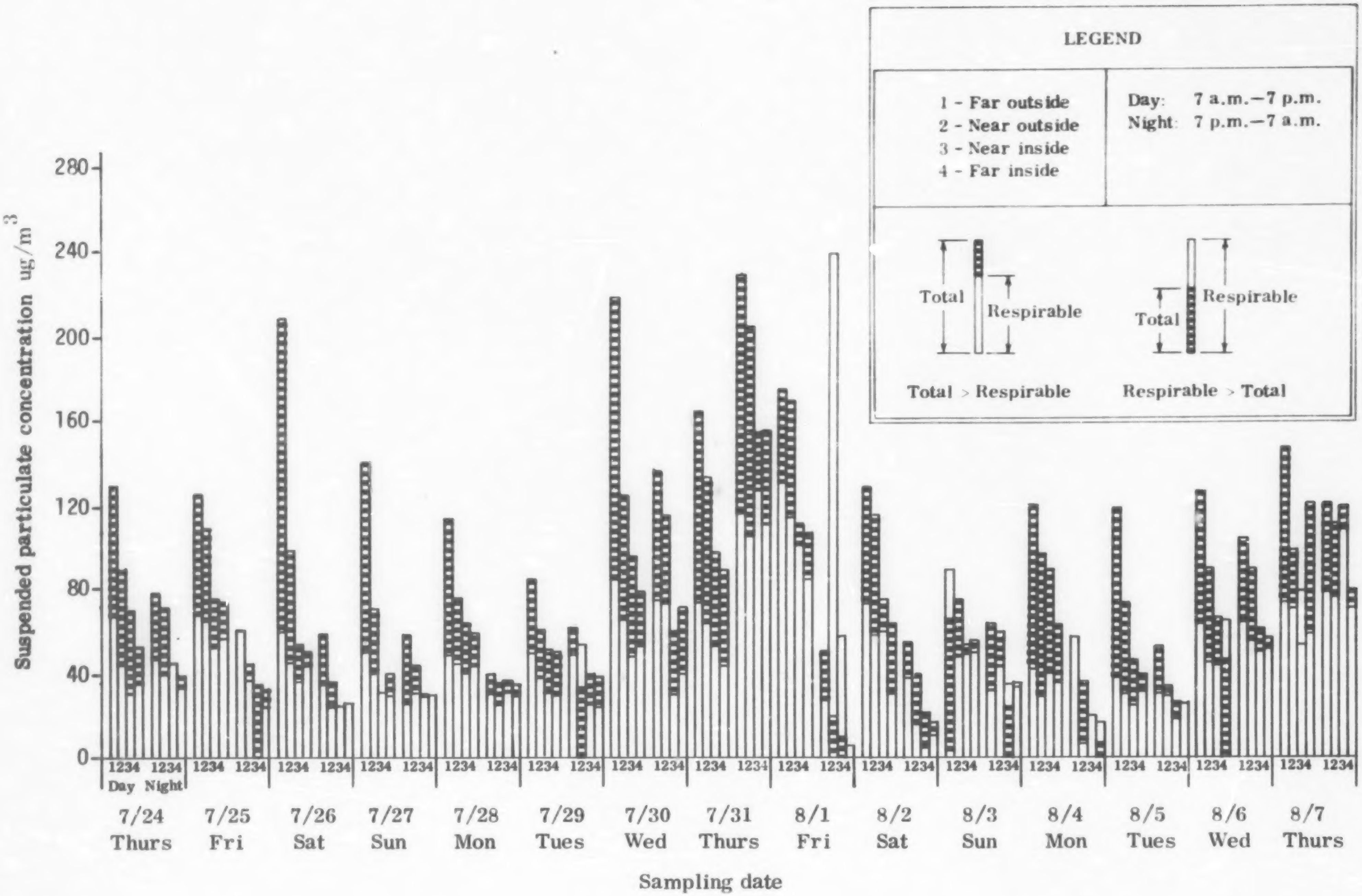
TABLE 5-4

DAY/NIGHT RATIOS FOR TOTAL SUSPENDED PARTICULATE—SUMMER SEASON

	100 Constitution Plaza				250 Constitution Plaza			
	Far outside	Near outside	Near inside	Far inside	Far outside	Near outside	Near inside	Far inside
22 Aug '69	0.85	1.10	0.97	1.45	0.87	1.00	0.43	0.64
23	0.92	0.85	1.39	0.77	0.82	0.91	—	0.38
24 Sunday	0.56	0.71	1.33	0.77	0.66	0.66	0.35	0.29
25	1.41	1.40	1.10	1.46	1.24	1.15	1.31	1.76
26	1.60	1.60	2.02	2.00	1.14	1.08	1.13	1.18
27	0.69	0.70	0.72	0.76	1.24	1.30	1.39	2.28
28	1.32	1.19	1.01	1.11	1.27	1.26	0.87	0.82
29	0.98	1.52	1.00	0.81	1.10	0.93	0.68	0.76
30	1.36	1.34	0.71	0.73	1.58	2.12	1.71	1.40
31 Sunday	0.95	0.95	0.90	1.14	0.95	0.95	0.81	0.78
1 Sept '69	0.79	0.90	0.91	1.00	0.85	0.85	0.78	0.86
2	—	—	—	—	—	—	—	—
Ratio of Average	1.12	1.20	1.00	1.14	1.13	1.93	0.85	0.93

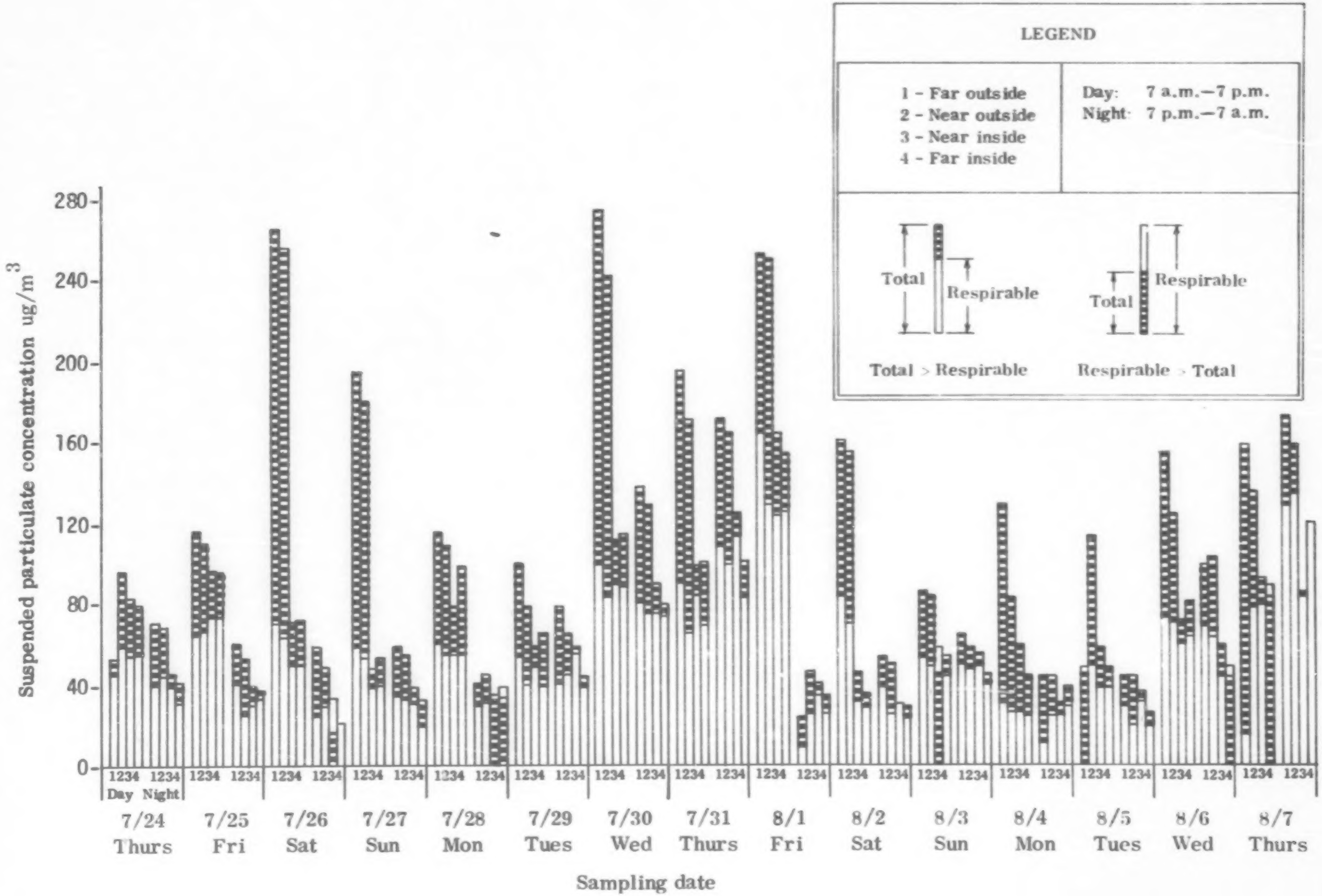
TABLE 5-5
DAY/NIGHT RATIOS FOR TOTAL SUSPENDED PARTICULATE—SUMMER SEASON

Date	Blinn Street				Carroll Road			
	Far outside	Near outside	Near inside	Far inside	Far outside	Near outside	Near inside	Far inside
16 Sept '69	1.53	1.59	1.37	1.39	1.50	1.49	1.39	1.89
17	5.04	7.62	4.13	3.24	5.15	8.27	5.00	5.75
18	1.02	1.16	2.00	1.67	0.75	1.00	1.80	1.74
19	1.26	0.95	0.86	1.29	0.63	0.83	1.22	1.33
20	—	—	1.36	1.05	1.41	2.64	1.70	1.52
21 Sunday	0.57	0.75	1.05	1.36	0.40	0.42	5.06	4.98
22	0.93	1.08	0.97	1.04	0.82	0.60	1.03	0.79
23	0.96	0.86	1.04	1.12	0.85	0.85	1.28	1.07
24	1.18	1.20	1.04	0.92	0.40	0.66	1.26	1.09
25	2.24	1.96	1.81	1.54	2.16	1.91	—	—
26	1.72	2.09	1.02	1.22	2.32	1.46	1.12	1.09
27	0.70	1.52	1.43	1.76	2.40	1.40	0.73	1.49
28 Sunday	0.97	1.80	1.25	1.22	2.31	2.04	0.79	2.31
29	0.77	0.95	0.63	—	0.61	0.67	1.12	0.84
Ratio of Average	1.21	1.34	1.31	1.35	1.18	1.22	1.25	1.62



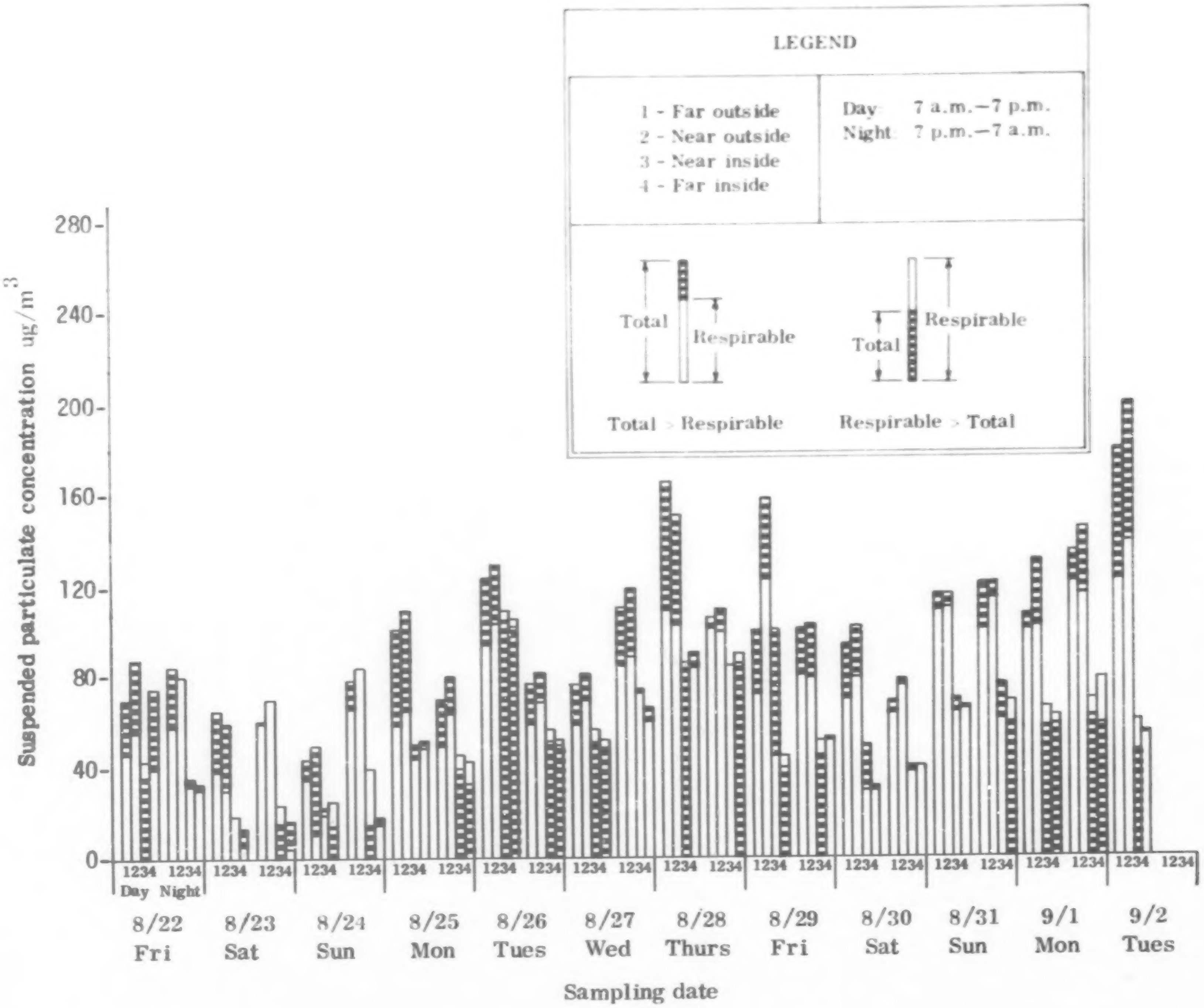
Suspended Particulate Concentrations at Hartford Library/Summer Season

FIGURE 5-1



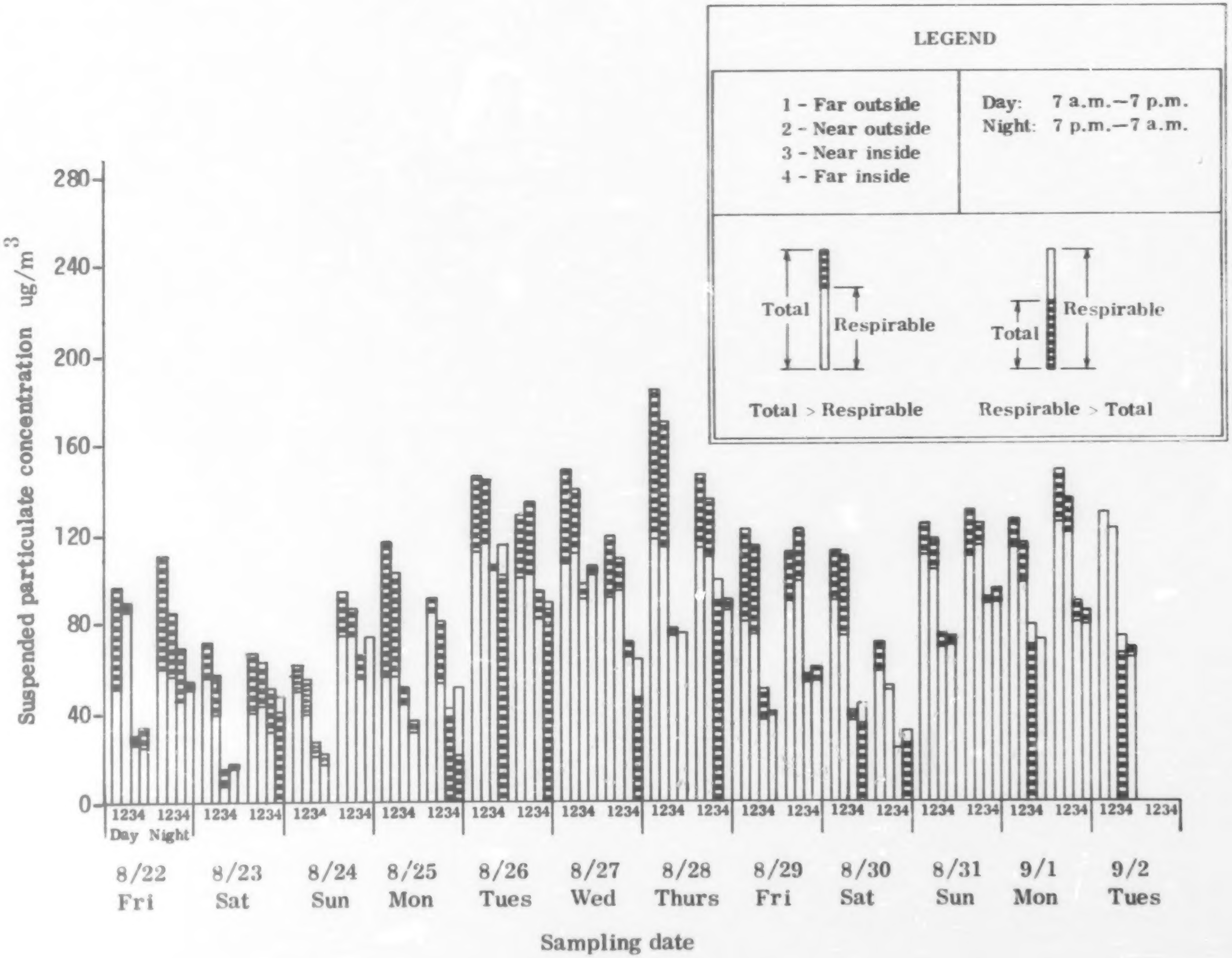
Suspended Particulate Concentrations at Hartford City Hall/Summer Season

FIGURE 5-2



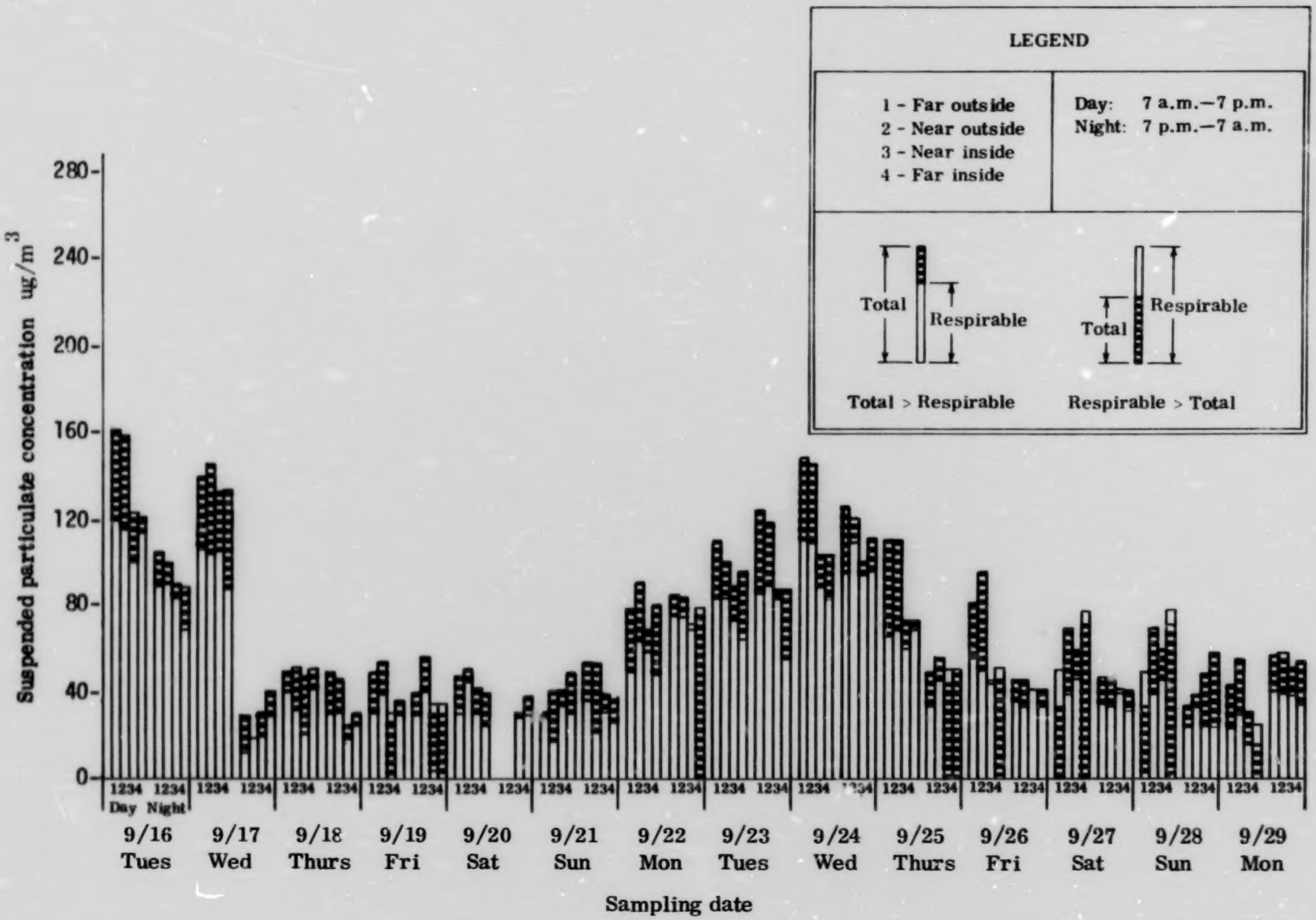
Suspended Particulate Concentrations at 100 Constitution Plaza/Summer Season

FIGURE 5-3



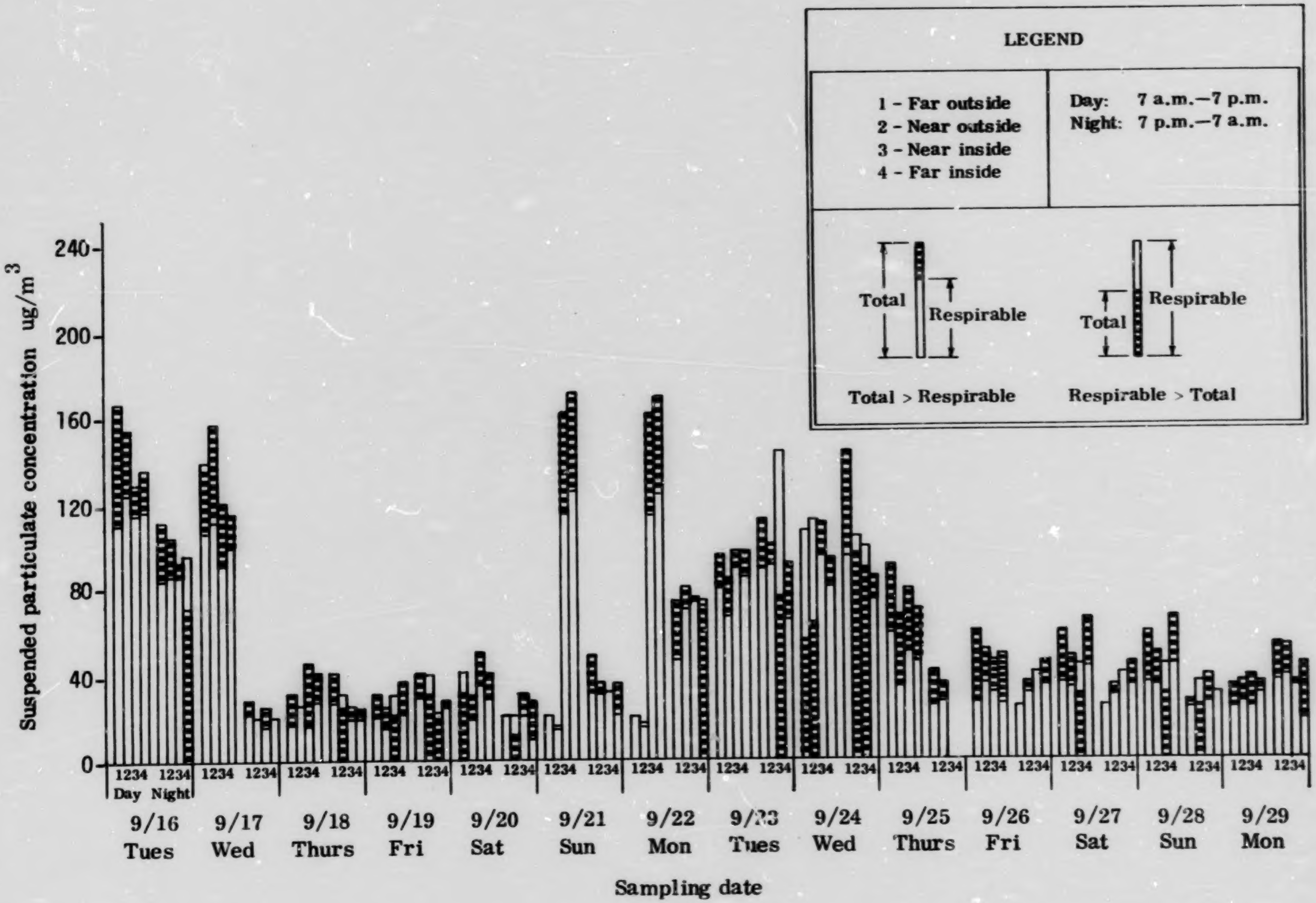
Suspended Particulate Concentrations at 250 Constitution Plaza/Summer Season

FIGURE 5-4



Suspended Particulate Matter Concentration at Blinn Street/Summer Season

FIGURE 5-5



Suspended Particulate Concentrations at Carroll Road/Summer Season

FIGURE 5-6

collections in each pair were nearly always within 5 percent of each other. Far inside/far outside ratios and day/night ratios are presented in Table 5-7.

Data on the winter program follows the same format. Table 5-8 lists the mass collections of suspended particulate, Table 5-9 the far inside/far outside ratios of collections, and the day/night ratios.

With the discontinuance of the prefilter approach to the measurement of respirable particulate fraction, two fractionating particle sampling systems based on the Andersen multi-stage, multi-jet impactor were obtained from NAPCA and employed as an outside/inside pair at each structure in turn. Results for the fall and winter programs are presented in Tables 5-10 and 5-11 respectively.

The organic material in selected collections, representing either far outside or far inside concentrations for either one week of daytime or of nighttime exposures was extracted with benzene and the data are presented in Table 5-12 for all three seasons. Each determination is presented both in absolute terms as an atmospheric concentration and as a proprotion of total particulate collection in percent. For the summer program we have inserted the corresponding data from the respirable collections, despite the uncertainty regarding the validity of the filter techniques. If the problem arises with the shedding of particles from the poluurethane pre - filter foam, then the mass of prefiltered benzene extractable material should be valid as the polyurethane appears not to be soluble in

TABLE 5-6
SUSPENDED PARTICULATE-FALL-$\mu g/m^3$

Sample Point	Library		City Hall		100 Const. Pl.		250 Const. Pl.		Blinn Street		Carroll Rd.	
	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
Far Outside												
First Week	135	106	127	103	49	39	67	45	89	61	67	51
Second Week	165	94	139	86	47	37	65	47	103	87	89	71
Average	150	100	133	94	48	38	66	46	96	74	78	61
Near Outside												
First Week	114	88	124	93	50	39	57	44	86	58	75	50
Second Week	116	66	133	73	44	41	59	44	100	82	87	71
Average	115	77	128	83	47	40	58	44	93	70	81	60
Near Inside												
First Week	64	53	85	58	40	30	44	28	46	33	74	35
Second Week	58	39	89	43	28	18	32	20	58	51	72	38
Average	61	46	87	50	34	24	38	24	52	42	73	37
Far Inside												
First Week	61	51	80	59	43	32	43	25	48	35	77	37
Second Week	53	37	84	41	29	22	33	20	60	55	75	39
Average	57	44	82	50	36	27	38	23	54	45	76	38
PERIOD	Oct 9 to Oct 23				Oct 31 to Nov 14				Nov 19 to Dec 3			

TABLE 5-7

SUSPENDED PARTICULATE RATIOS - FALL 1969

Sample Point	Library		City Hall		100 Const. Pl.		250 Const. Pl.		Blinn Street		Carroll Road	
	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
FAR INSIDE/FAR OUTSIDE RATIO:												
First Week	0.45	0.48	0.63	0.57	0.88	0.82	0.64	0.56	0.54	0.57	1.15	0.73
Second Week	0.32	0.39	0.60	0.48	0.62	0.58	0.51	0.42	0.58	0.63	0.84	0.55
Of Average	0.38	0.44	0.62	0.53	0.75	0.71	0.58	0.50	0.56	0.61	0.97	0.62
DAY/NIGHT RATIO:												
Far Outside:												
First Week	1.27		1.23		1.26		1.49		1.46		1.31	
Second Week	1.76		1.62		1.27		1.34		1.18		1.25	
Of Average	1.50		1.41		1.26		1.43		1.30		1.28	
Near Outside:												
First Week	1.16		1.33		1.28		1.29		1.48		1.50	
Second Week	1.76		1.82		1.07		1.34		1.22		1.22	
Of Average	1.49		1.54		1.17		1.32		1.33		1.35	
Near Inside:												
First Week	1.21		1.46		1.33		1.57		1.39		2.12	
Second Week	1.49		2.07		1.55		1.60		1.14		1.89	
Of Average	1.33		1.74		1.42		1.58		1.24		1.97	
Far Inside:												
First Week	1.20		1.35		1.34		1.72		1.37		2.08	
Second Week	1.43		2.05		1.32		1.65		1.09		1.92	
Of Average	1.29		1.64		1.33		1.65		1.20		2.00	

TABLE 5-8

SUSPENDED PARTICULATE—WINTER SEASON-$\mu g/m^3$

Sample Point	Library		City Hall		100 Const. Pl.		250 Const. Pl.		Blinn Street		Carroll Rd.	
	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
Far Outside												
First Week	390	180	334	169	92	60	125	72	137	110	94	84
Second Week	460	198	320	167	156	102	241	122	91	62	112	86
Average	425	189	327	168	124	81	183	97	114	86	103	85
Near Outside												
First Week	271	126	274	148	98	67	109	79	143	98	101	88
Second Week	316	135	296	146	177	111	217	117	75	60	131	74
Average	293	130	285	147	137	89	163	98	109	79	116	81
Near Inside												
First Week	71	53	97	55	36	28	53	22	50	39	67	36
Second Week	77	49	117	51	42	54	61	40	40	25	28	28
Average	74	51	107	53	39	41	57	31	45	32	44	32
Far Inside												
First Week	65	46	81	54	36	33	54	23	52	40	75	36
Second Week	69	44	93	48	40	45	66	42	46	29	31	30
Average	67	45	87	51	38	39	60	32	49	35	53	33
PERIOD	Jan 12 to Jan 26				Jan 30 to Feb 13				Feb 26 to Mar 12			

TABLE 5-8

SUSPENDED PARTICULATE—WINTER SEASON-$\mu g/m^3$

Sample Point	Library		City Hall		100 Const. Pl.		250 Const. Pl.		Blinn Street		Carroll Rd.	
	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
Far Outside												
First Week	390	180	334	169	92	60	125	72	137	110	94	84
Second Week	460	198	320	167	156	102	241	122	91	62	112	86
Average	425	189	327	168	124	81	183	97	114	86	103	85
Near Outside												
First Week	271	126	274	148	98	67	109	79	143	98	101	88
Second Week	316	135	296	146	177	111	217	117	75	60	131	74
Average	293	130	285	147	137	89	163	98	109	79	116	81
Near Inside												
First Week	71	53	97	55	36	28	53	22	50	39	67	36
Second Week	77	49	117	51	42	54	61	40	40	25	28	28
Average	74	51	107	53	39	41	57	31	45	32	44	32
Far Inside												
First Week	65	46	81	54	36	33	54	23	52	40	75	36
Second Week	69	44	93	48	40	45	66	42	46	29	31	30
Average	67	45	87	51	38	39	60	32	49	35	53	33
PERIOD	**Jan 12 to Jan 26**				**Jan 30 to Feb 13**				**Feb 26 to Mar 12**			

TABLE 5-9

SUSPENDED PARTICULATE RATIOS - WINTER 1970

Sample Point	Library		City Hall		100 Const. Pl.		250 Const. Pl.		Blinn Street		Carroll Road	
	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
FAR INSIDE/FAR OUTSIDE RATIO:												
First Week	0.17	0.26	0.24	0.32	0.39	0.55	0.43	0.32	0.38	0.36	0.80	0.43
Second Week	0.15	0.22	0.29	0.29	0.26	0.44	0.27	0.35	0.51	0.47	0.28	0.35
Of Average	0.16	0.24	0.27	0.30	0.31	0.48	0.33	0.33	0.43	0.41	0.51	0.39
DAY/NIGHT RATIO:												
Far Outside:												
First Week	2.16		1.97		1.53		1.74		1.24		1.12	
Second Week	2.32		1.92		1.53		1.97		1.47		1.30	
Of Average	2.25		1.95		1.53		1.89		1.32		1.21	
Near Outside:												
First Week	2.15		1.82		1.46		1.38		1.46		1.15	
Second Week	2.34		2.03		1.59		1.85		1.25		1.77	
Of Average	2.26		1.94		1.54		1.66		1.38		1.43	
Near Inside:												
First Week	1.34		1.74		1.28		2.41		1.28		1.86	
Second Week	1.57		2.29		0.78		1.52		1.60		1.00	
Of Average	1.45		2.02		0.95		1.84		1.41		1.37	
Far Inside:												
First Week	1.41		1.50		1.09		2.35		1.30		2.08	
Second Week	1.57		1.94		0.89		1.59		1.59		1.03	
Of Average	1.49		1.70		0.98		1.87		1.40		1.61	

TABLE 5-10

PARTICLE SIZE DISTRIBUTIONS ($\mu g/m^3$)

SAMPLE: 7:00 A.M. - 7:00 P.M. for 3 Days

FALL SEASON 1969

LOCATION PERIOD IMPACTOR STAGE: NUMBER	CUTOFF (6 cfm)	LIBRARY Nov. 18-20 Outside	Inside	CITY HALL Nov. 7-9 ** Outside	** Inside	100 CONST. PL. Nov. 10-12 Outside	Inside	250 CONST. PL. Nov. 14-16 Outside	* Inside	25 BLINN STREET Nov. 24-26 Outside	Inside	60 CARROLL ROAD Dec. 3-5 Outside	Inside
1	2.54 µm.	17.4	3.8	2.2	0	4.9	0	5.4	0	9.5	4.1	13.9	3.5
2	1.88	2.7	1.6	1.1	0	0.3	1.1	0.8	0	1.6	1.6	1.6	0
3	1.29	1.4	0.5	1.9	0	0.3	0	1.4	0	1.4	1.1	1.6	0
4	0.80	2.2	1.1	3.0	0.5	1.6	0	3.0	0.5	3.3	1.1	1.9	1.9
5	0.44	3.5	4.4	6.8	4.1	1.1	5.0	5.7	1.6	5.7	4.4	1.1	5.4
Backup Filter		11.2	19.1	9.0	13.1	13.6	30.2	18.0	0.5	20.4	12.3	10.4	15.8
Total Collection		38.4	30.5	24.0	17.7	21.8	36.3	34.3	2.6	41.9	24.6	30.5	26.6

** Data considered unreliable

* Suspect an undetected measurement failure.

TABLE 5-11

PARTICLE SIZE DISTRIBUTIONS ($\mu g/m^3$)

SAMPLE: 7:00 A.M. - 7:00 P.M. for 3 Days

WINTER SEASON 1970

LOCATION		LIBRARY		CITY HALL		100 CONST. PL.		250 CONST. PL.		25 BLINN STREET		60 CARROLL ROAD	
PERIOD		Jan. 20-22		Jan. 13-15		Feb. 3-5		Feb. 10-12		Mar. 3-5		Mar. 10-12	
IMPACTOR STAGE: NUMBER	CUTOFF (6 cfm)	Outside	Inside	Outside	Inside	Outside	Inside	Outside	Inside	Outside	Inside	Outside	Inside
1	2.54 µm.	72.5	7.4	30.2	4.3	9.0	1.1	13.1	5.4	2.7	5.7	17.2	13.9
2	1.88	9.8	2.7	4.1	1.6	3.5	0	5.4	1.6	0.3	0.5	3.5	4.1
3	1.29	6.0	3.3	3.3	1.9	1.9	0	3.3	1.4	0.5	0.0	3.8	3.5
4	0.80	5.2	1.6	1.9	2.7	3.0	1.4	4.1	2.5	0.8	0.5	5.7	3.5
5	0.44	7.9	5.4	4.1	9.0	6.5	6.0	5.7	6.3	2.5	3.5	9.8	10.9
Backup Filter		35.7	28.9	22.9	29.1	16.1	27.8	18.3	20.2	12.8	17.2	24.8	24.0
Total Collection		137.1	49.3	66.5	48.6	40.0	36.3	49.9	37.4	19.6	27.4	64.8	59.9

TABLE 5-12
BENZENE SOLUBLE FRACTION
of
SUSPENDED PARTICULATES

NOTE: Bracketed values are corresponding measurements of "respirable" collections

LOCATION	SUMMER				FALL				WINTER			
	DAY		NIGHT		DAY		NIGHT		DAY		NIGHT	
	µg/m3	%	µg/m3	%	µg/m3	%	µg/m3	%	µg/m3	%	µg/m3	%
LIBRARY	(25-31 July)				(9-16 October)				(19-26 January)			
Far Outside	9.8[10.0]	8.3[13.8]	7.0[6.0]	7.6[11.2]	16.1	12.0	13.6	12.9	29.5	6.4	12.4	6.3
Far Inside	6.6[6.0]	10.3[14.1]	11.9[12.2]	23.4[26.9]	11.7	18.9	12.1	23.5	13.9	20.0	6.0	13.6
CITY HALL	(25-31 July)				(9-16 October)				(19-26 January)			
Far Outside	21.8[15.7]	12.0[21.8]	10.5[8.9]	12.1[17.3]	22.8	18.2	21.8	20.6	25.3	7.9	10.9	6.5
Far Inside	17.1[16.5]	19.9[27.6]	12.3[14.3]	24.3[37.9]	23.3	29.3	11.3	19.3	24.6	26.5	5.5	11.5
100 C.P.	(22-25, 28-30 August)				(31 October - 7 November)				(6-13 February)			
Far Outside	19.0[13.2]	22.0[22.2]	14.0[15.0]	16.0[27.6]	6.2	12.5	5.5	14.3	13.0	8.3	11.9	11.8
Far Inside	20.5[21.0]	53.7[54.3]	20.6[7.9]	50.1[18.1]	16.5	38.0	5.0	15.6	10.2	25.6	8.7	19.1
250 C.P.	(22-25, 28-30 August)				(31 October - 7 November)				(6-13 February)			
Far Outside	17.0[10.8]	15.9[14.6]	12.3[10.4]	12.8[14.2]	7.8	11.8	7.8	17.5	21.9	9.1	16.7	13.6
Far Inside	17.4[8.1]	47.5[23.1]	11.9[13.9]	23.8[24.6]	12.1	28.3	5.2	21.0	14.5	22.2	8.6	20.4
BLINN STREET	(23-29 September)				(26 November - 3 December)				(26 February - 5 March)			
Far Outside	18.4[17.4]	20.2[22.2]	11.5[13.2]	13.9[21.4]	16.7	16.2	16.9	19.5	11.0	8.3	12.7	11.6
Far Inside	* 2.9[8.1]	* 3.3[9.4]	17.3[14.9]	23.0[6.2]	13.9	23.2	16.3	31.3	11.8	22.4	5.5	13.6
CARROLL ROAD	(23-29 September)				(26 November - 3 December)				(26 February - 5 March)			
Far Outside	13.5[12.9]	16.3[20.5]	19.8[15.4]	29.0[30.0]	12.7	14.0	11.9	16.4	9.1	9.7	10.5	12.7
Far Inside	18.7[23.4]	21.5[37.2]	17.8[21.3]	26.6[45.2]	22.9	30.3	9.5	24.4	25.6	34.5	5.3	14.6

*suspect

TABLE 5-13
INORGANIC LEAD FRACTION
OF
SUSPENDED PARTICULATES

LOCATION	SUMMER				FALL				WINTER			
	DAY		NIGHT		DAY		NIGHT		DAY		NIGHT	
	µg/m^3	%	µg/m^3	%	µg/m^3	%	µg/m^3	%	µg/m^3	%	µg/m^3	%
LIBRARY	(25-31 July)				(9-16 October)				(19-26 January)			
Far Outside	1.58	1.3	.72	.78	3.78	2.80	3.44	3.26	3.34	.73	1.68	.85
Far Inside	.77	1.2	.39	.77	2.04	3.30	1.68	3.26	1.40	2.02	.44	.99
CITY HALL	(25-31 July)				(9-16 October)				(19-26 January)			
Far Outside	.87	.48	.48	.55	*1.06	* .85	3.68	3.46	2.71	.85	1.61	.96
Far Inside	.92	1.07	.44	.87	1.62	2.10	2.04	3.49	1.85	1.98	.99	2.07
100 C.P.	(22-25,28-30 August)				(31 October - 7 November)				(6-13 February)			
Far Outside	.46	.53	.36	.41	1.19	2.65	.86	2.24	1.68	1.08	1.98	1.96
Far Inside	.18	.47	.27	.66	.46	1.08	* 1.19	* 3.72	.59	1.48	1.26	2.78
250 C.P.	(22-25,28-30 August)				(31 October - 7 November)				(6-13 February)			
Far Outside	.38	.36	.55	.57	2.04	3.05	1.13	2.54	2.72	1.14	1.83	1.49
Far Inside	.35	.96	* 1.46	* 2.92	.72	1.68	.46	1.86	.86	1.32	1.26	3.00
BLINN STREET	(23-29 September)				(26 November - 3 December)				(26 February - 5 March)			
Far Outside	1.86	2.10	2.68	3.24	3.94	3.82	2.79	3.22	2.42	1.83	1.19	1.09
Far Inside	1.59	1.81	1.75	2.33	1.54	2.57	1.33	2.56	1.26	2.38	.77	1.91
CARROLL ROAD	(23-29 September)				(26 November - 3 December)				(26 February - 5 March			
Far Outside	.75	.91	1.66	2.43	1.68	1.85	2.19	3.02	1.19	1.27	.57	.69
Far Inside	.75	.86	1.20	1.79	.93	1.23	1.33	3.42	.47	.63	* .89	* 2.45

*suspect

benzene.

The inorganic lead content of the same filter collections were measured after the benzene extractions and are presented in Table 5-13 for all three seasons. Through the atomic absorption measurement for lead in benzene extracts from heavy filter collections, we satisfied ourselves that no measureable lead was lost in the sequential extraction process. The procedure for the determination of lead content was patterned after the NASN procedures for lead extraction. The samples were analyzed by atomic absorption spectrophotometry at an independent commercial laboratory. An analysis check in an institutional laboratory showed variations seldom exceeding 20 percent.

There are no bulk data concerning suspended particulates in the data supplements to this volume.

5.2 Soiling Particulates

Soiling particulate data have been averaged on a 12-hour basis corresponding to the suspended particulate sample periods and are presented in similar tables. The soiling indexes for the summer season are presented in Tables 5-14 to 5-16, for the fall season in Tables 5-17 to 5-19, and for the winter season in Tables 5-20 to 5-22. The basic 2-hour data are reported in the respective data supplements to this volume.

The far inside/far outside ratios of the 12-hour averages are presented in Tables 5-23 to 5-25 for the three seasons. The ratio of the average far inside to the average far outside soiling index is the final figure in each column.

TABLE 5-14

SOILING PARTICULATE INDEX, COH PER 1000 LINEAL FEET - SUMMER SEASON

	Public Library								City Hall							
	Far Outside		Near Outside		Near Inside		Far Inside		Far Outside		Near Outside		Near Inside		Far Inside	
1969	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day
21-22 July	0.31	0.50	0.28	0.52	0.25	0.43	0.27	0.44	0.28	0.50	0.26	0.47	0.26	0.50	0.25	0.53
22-23	0.32	0.39	0.33	0.33	0.28	0.30	0.30	0.32	0.33	0.38	0.30	0.32	0.33	0.37	0.35	0.39
23-24	0.40	0.36	0.41	0.34	0.29	0.29	0.33	0.35	0.35	0.32	0.36		0.33	0.33	0.33	0.36
24-25	0.35	0.39	0.36	0.38	0.27	0.31	0.29	0.33	0.33	0.36	0.32	0.35	0.30	0.37	0.29	0.39
25-26	0.19	0.28	0.18	0.24	0.13	0.17	0.17	0.27		0.34		0.30		0.29		0.30
26-27 (Sun)	0.10	0.18	0.10	0.14	0.06	0.11	0.10	0.13	0.15	0.19	0.09	0.18	0.10	0.17	0.10	0.17
27-28	0.14	0.25	0.15	0.22	0.10	0.19	0.13	0.25	0.17	0.31	0.13	0.27	0.13	0.27	0.14	0.30
28-29	0.15	0.43	0.15	0.36	0.11	0.30	0.10	0.31	0.15	0.42	0.15	0.41	0.15	0.40	0.17	0.40
30-31	0.31	0.44	0.30	0.42	0.25	0.38	0.27	0.41	0.31	0.50	0.32	0.49	0.29	0.49	0.31	0.51
31-1 Aug	0.42	0.43	0.43	0.40	0.34	0.35	0.35	0.34	0.37	0.49	0.42	0.44	0.42	0.44	0.42	0.46
1-2	0.46	0.47	0.47	0.48	0.39	0.41	0.41	0.40	0.46	0.53	0.47	0.50	0.44	0.48	0.46	0.48
2-3 (Sun)	0.22	0.29	0.22	0.30	0.18	0.25	0.19	0.29	0.20	0.29	0.21	0.31	0.21	0.29	0.23	0.30
3-4	0.18	0.31	0.19	0.29	0.15	0.25	0.16	0.24	0.19	0.25	0.21	0.27	0.19	0.26	0.20	0.27
4-5	0.31	0.48	0.28	0.41	0.22	0.37	0.21	0.40	0.27	0.43	0.29	0.51	0.25	0.44	0.27	0.45
5-6	0.28	0.47	0.25	0.40	0.22	0.34	0.22	0.32	0.23	0.40	0.30	0.42	0.25	0.39	0.27	0.40
6-7	0.35	0.48	0.31	0.43	0.30	0.43	0.27	0.38	0.27	0.43	0.31	0.43	0.27	0.41	0.28	0.44
7-8	0.56	0.55	0.49	0.49	0.47	0.51	0.40	0.43	0.45	0.45	0.50	0.51	0.38	0.46	0.43	0.48
8-9	0.56	0.80	0.50	0.73	0.50	0.70	0.41	0.59	0.55	0.71	0.62	0.90	0.51	0.62	0.52	0.60
Average	0.31	0.42	0.30	0.38	0.25	0.34	0.25	0.34	0.30	0.41	0.31	0.42	0.28	0.39	0.30	0.40

TABLE 5-15

SOILING PARTICULATE INDEX, COH PER 1000 LINEAL FEET - SUMMER SEASON

	100 Constitution Plaza								250 Constitution Plaza							
	Far Outside		Near Outside		Near Inside		Far Inside		Far Outside		Near Outside		Near Inside		Far Inside	
1969	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day
21-22 Aug.	0.44	0.22			0.35	0.20	0.38	0.22	0.67	0.37	0.68	0.40	0.51	0.27	0.42	0.21
22-23	0.46	0.27			0.44	0.13	0.42	0.14	0.67	0.41	0.75	0.41	0.65	0.22	0.50	0.15
23-24 (Sun)	0.28	0.16			0.20	0.20	0.20	0.23	0.46	0.29	0.45	0.32	0.36	0.20	0.29	0.15
24-25	0.46	0.26		0.30	0.27	0.26	0.28	0.25	0.74	0.50	0.79	0.55	0.62	0.28	0.54	0.21
25-26	0.20	0.21	0.31	0.33	0.20	0.22	0.19	0.21	0.36	0.40	0.42	0.45	0.24	0.27	0.17	0.21
26-27									0.30	0.33	0.34	0.37	0.18	0.24	0.14	0.17
27-28		0.37		0.60		0.28		0.26	0.48	0.50	0.50	0.55	0.32	0.30	0.25	0.24
28-29	0.33	0.35	0.49	0.49	0.28	0.27	0.26	0.28	0.40	0.51	0.47	0.46	0.27	0.30	0.21	0.25
29-30	0.45	0.32	0.58	0.42	0.34	0.20	0.34	0.19	0.63	0.46	0.65	0.51	0.41	0.27	0.33	0.22
30-31 (Sun)	0.19	0.27	0.27	0.36	0.20	0.32	0.17	0.31	0.29	0.38	0.33	0.45	0.20	0.38	0.13	0.31
31-1 Sept.	0.35	0.27	0.46	0.37	0.34	0.38	0.31	0.36	0.46	0.43	0.52	0.48	0.45	0.43	0.36	0.37
1-2	0.45	0.53	0.60	0.69	0.45	0.41	0.41	0.38	0.67	0.79	0.76	0.87	0.57	0.50	0.52	0.42
2-3	0.36	0.37	0.46	0.46	0.37	0.32	0.33	0.30	0.54	0.58	0.57	0.63	0.35	0.41	0.31	0.34
3-4	0.39	0.34	0.47	0.44	0.33	0.26	0.33	0.27	0.55	0.53	0.58	0.57	0.35	0.39	0.31	0.34
Average	0.36	0.30	0.45	0.45	0.31	0.27	0.30	0.26	0.52	0.46	0.56	0.50	0.39	0.32	0.32	0.26

TABLE 5-16

SOILING PARTICULATE INDEX, COH PER 1000 LINEAL FEET - SUMMER SEASON

	Blinn Street								Carroll Road							
	Far Outside		Near Outside		Near Inside		Far Inside		Far Outside		Near Outside		Near Inside		Far Inside	
1969	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day
10-11 Sept.	0.59	0.40	0.55	0.36	0.52	0.37	0.52	0.33								
11-12	0.67	0.48	0.67	0.45	0.54	0.43	0.46	0.38								
12-13	0.54	0.45	0.48	0.43	0.44	0.38	0.36	0.34								
13-14 (Sun)	0.67	0.47	0.64	0.46	0.55	0.45	0.47	0.36								
14-15	0.32	0.55	0.29	0.52	0.31	0.51	0.23	0.42								
15-16	0.58	0.64	0.59	0.57	0.60	0.55	0.53	0.47	0.64	0.63	0.66	0.69	0.60	0.57	0.75	0.67
16-17	0.60	0.59	0.57	0.62	0.56	0.58	0.48	0.49	0.60	0.56	0.69	0.64	0.54	0.52	0.65	0.63
17-18	0.40	0.41	0.37	0.39	0.37	0.37	0.32	0.32	0.15	0.17	0.18	0.19	0.14	0.13	0.16	0.18
18-19	0.58	0.46	0.58	0.46	0.48	0.38	0.42	0.36	0.25	0.19	0.29	0.24	0.21	0.17	0.24	0.21
19-20	0.57	0.40	0.53	0.36	0.45	0.34	0.37	0.31	0.38	0.23	0.41	0.26	0.28	0.23	0.31	0.25
20-21 (Sun)	0.32	0.22	0.37	0.28	0.31	0.24	0.26	0.20	0.27	0.21	0.33	0.22	0.24	0.20	0.28	0.25
21-22	0.47	0.49	0.63	0.51	0.50	0.52	0.40	0.44	0.37	0.36	0.40	0.41	0.35	0.34	0.41	0.40
22-23	0.63	0.53	0.63	0.54	0.67	0.61	0.58	0.50	0.56	0.45	0.60	0.48	0.47	0.39	0.57	0.46
23-24	0.79	0.59	0.79	0.61	0.92	0.67	0.79	0.59	0.65	0.53	0.65	0.51	0.55	0.57	0.62	0.60
24-25	0.81	0.59	0.83	0.59	0.92	0.65	0.80	0.59	0.63	0.36	0.63	0.35	0.69	0.43	0.85	0.74
25-26	0.40	0.46	0.40	0.47	0.46	0.55	0.40	0.48	0.18	0.19	0.18	0.20	0.19	0.24	0.17	0.21
26-27	0.38	0.37	0.38	0.35	0.44	0.46	0.37	0.37	0.15	0.27	0.15	0.28	0.18	0.35	0.17	0.28
27-28 (Sun)	0.30	0.15	0.30	0.16	0.37	0.19	0.35	0.23	0.22	0.09	0.22	0.09	0.27	0.15	0.29	0.07
28-29	0.46	0.30	0.46	0.30	0.51	0.37	0.44	0.32	0.24	0.14	0.24	0.12	0.28	0.18	0.27	0.17
29-30	0.56		0.56		0.60		0.50		0.47		0.45		0.53		0.51	
Average	0.53	0.44	0.53	0.43	0.52	0.44	0.45	0.39	0.38	0.32	0.40	0.35	0.37	0.33	0.42	0.38

TABLE 5-18

SOILING PARTICULATE INDEX, COH PER 1000 LINEAL FEET - FALL SEASON

	100 Constitution Plaza								250 Constitution Plaza							
	Far Outside		Near Outside		Near Inside		Far Inside		Far Outside		Near Outside		Near Inside		Far Inside	
1969	Night	Day	Night	Day	Night	Day	Night	Day	Night	Da	Night	Day	Night	Day	Night	Day
31-1 Nov.	0.37	0.20	0.41	0.23	0.43	0.16	0.30	0.09	0.40	0.23	0.43	0.23	0.41	0.19	0.35	0.16
1-2 (Sun)	0.20	0.17	0.23	0.20	0.23	0.19	0.20	0.13	0.25	0.19	0.26	0.19	0.21	0.20	0.20	0.18
2-3	0.12	0.23	0.15	0.28	0.14	0.24	0.10	0.23	0.12	0.25	0.14	0.26	0.12	0.18	0.12	0.17
3-4	0.38	0.34	0.42	0.38	0.38	0.29	0.33	0.26	0.38	0.32	0.38	0.32	0.32	0.26	0.30	0.24
4-5	0.22	0.21	0.25	0.26	0.22	0.22	0.18	0.19	0.21	0.30	0.21	0.28	0.15	0.24	0.15	0.23
5-6	0.18	0.37	0.21	0.40	0.14	0.29	0.12	0.25	0.17	0.36	0.17	0.34	0.13	0.29	0.13	0.32
6-7	0.25	0.38	0.28	0.42	0.20	0.29	0.15	0.27	0.27	0.36	0.29	0.39	0.22	0.36	0.20	0.32
7-8	0.30	0.27	0.35	0.29	0.29	0.17	0.26	0.13	0.30	0.27	0.32	0.27	0.24	0.17	0.22	0.18
8-9 (Sun)	0.22	0.11	0.26	0.14	0.17	0.12	0.12	0.08	0.23	0.12	0.24	0.12	0.21	0.09	0.20	0.10
9-10	0.07	0.19	0.09	0.23	0.08	0.20	0.36	0.15	0.11	0.22	0.11	0.21	0.06	0.21	0.09	0.20
10-11	0.13	0.20	0.15	0.67	0.13	0.19	0.09	0.14	0.13	0.18	0.14	0.22	0.12	0.18	0.13	0.18
11-12	0.25	0.50	0.29	0.55	0.22	0.33	0.17	0.29	0.26	0.46	0.25	0.44	0.21	0.35	0.21	0.33
12-13	0.30	0.26	0.34	0.33	0.30	0.23	0.27	0.18	0.31	0.36	0.30	0.31	0.31	0.24	0.29	0.23
13-14	0.43	0.30	0.47	0.37	0.39	0.24	0.34	0.21	0.43	0.27	0.43	0.31	0.41	0.28	0.37	0.28
Average	0.24	0.27	0.28	0.34	0.24	0.23	0.19	0.19	0.25	0.28	0.26	0.28	0.22	0.23	0.21	0.22

TABLE 5-19

SOILING PARTICULATE INDEX, COH PER 1000 LINEAL FEET - FALL SEASON

	Blinn Street								Carroll Road							
	Far Outside		Near Outside		Near Inside		Far Inside		Far Outside		Near Outside		Near Inside		Far Inside	
1969	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day
19-20 Nov.	0.17	0.22	0.21	0.26	0.20	0.26	0.16	0.22	0.13	0.17	0.13	0.15	0.11	0.11	0.11	0.11
20-21	0.25	0.22	0.27	0.26	0.26	0.25	0.23	0.21	0.19	0.17	0.19	0.18	0.14	0.13	0.14	0.14
21-22	0.26	0.25	0.29	0.28	0.27	0.27	0.23	0.22	0.16	0.31	0.21	0.29	0.10	0.22	0.12	0.24
22-23 (Sun)	0.31	0.45	0.32	0.47	0.31	0.47	0.24	0.38	0.36	0.50	0.38	0.52	0.21	0.32	0.23	0.32
23-24	0.39	0.27	0.44	0.30	0.44	0.27	0.36	0.25	0.42	0.18	0.40	0.13	0.30	0.15	0.30	0.15
24-25	0.45	0.38	0.54	0.48	0.48	0.51	0.42	0.41	0.39	0.52	0.37	0.48	0.19	0.35	0.20	0.37
25-26	0.41	0.39	0.45	0.43	0.42	0.44	0.37	0.35	0.56	0.41	0.57	0.41	0.38	0.33	0.38	0.32
26-27	0.36	0.15	0.39	0.17	0.37	0.16	0.32	0.14	0.37	0.22	0.36	0.22	0.24	0.19	0.23	0.20
27-28	0.45	0.45	0.47	0.48	0.45	0.49	0.38	0.40	0.46	0.43	0.47	0.46	0.25	0.37	0.26	0.38
28-29	0.63	0.51	0.70	0.55	0.70	0.55	0.58	0.46	0.62	0.57	0.61	0.57	0.39	0.37	0.39	0.39
29-30 (Sun)	0.41	0.20	0.43	0.22	0.42	0.23	0.35	0.20	0.41	0.20	0.39	0.18	0.31	0.18	0.33	0.21
30-1 Dec.	0.26	0.49	0.26	0.51	0.24	0.53	0.20	0.42	0.30	0.49	0.31	0.50	0.19	0.34	0.19	0.37
1-2	0.29	0.29	0.27	0.30	0.24	0.26	0.21	0.23	0.23	0.19	0.21	0.19	0.19	0.25	0.20	0.26
2-3	0.30	0.40	0.30	0.39	0.27	0.38			0.38	0.46	0.39	0.48	0.24	0.34	0.24	0.33
Average	0.35	0.33	0.38	0.36	0.36	0.36	0.31	0.30	0.36	0.34	0.36	0.33	0.23	0.26	0.24	0.26

TABLE 5-20

SOILING PARTICULATE COH PER 1000 LINEAL FEET - WINTER SEASON

	Public Library								City Hall							
	Far Outside		Near Outside		Near Inside		Far Inside		Far Outside		Near Outside		Near Inside		Far Inside	
1970	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day
12-13 Jan.	0.61	0.62	0.52	0.57	0.30	0.34	0.28	0.33	0.56	0.58	0.68	0.67	0.62	0.68	0.45	0.50
13-14	0.29	0.42	0.23	0.25	0.15	0.16	0.14	0.15	0.24	0.38	0.31	0.44	0.32	0.44	0.22	0.32
14-15	0.25	0.48	0.19	0.38	0.10	0.20	0.11	0.18	0.23	0.44	0.28	0.50	0.27	0.46	0.19	0.35
15-16	0.55	0.75	0.44	0.62	0.25	0.39	0.22	0.34	0.48	0.67	0.61	0.80	0.56	0.82	0.40	0.62
16-17	0.69	0.78	0.61	0.68	0.40	0.46	0.37	0.41	0.62	0.75	0.76	0.85	0.82	0.82	0.61	0.64
17-18 (Sun)	0.75	0.36	0.72	0.29	0.51	0.20	0.44	0.19	0.80	0.28	0.87	0.36	0.91	0.40	0.74	0.30
18-19	0.32	0.54	0.25	0.38	0.13	0.24	0.12	0.22	0.23	0.40	0.31	0.52	0.27	0.50	0.21	0.39
19-20	0.50	0.73	0.44	0.59	0.25	0.39	0.23	0.37	0.47	0.67	0.55	0.79	0.50	0.80	0.39	0.62
20-21	0.45	0.43	0.37	0.35	0.25	0.20	0.23	0.19	0.37	0.41	0.49	0.51	0.48	0.51	0.38	0.39
21-22	0.26	0.54	0.20	0.43	0.10	0.23	0.10	0.21	0.19	0.48	0.28	0.55	0.24	0.50	0.19	0.41
22-23	0.63	0.74	0.49	0.64	0.31	0.40	0.27	0.41	0.53	0.64	0.69	0.81	0.63	0.78	0.52	0.64
23-24	0.49	0.50	0.44	0.40	0.28	0.25	0.26	0.24	0.45	0.39	0.55	0.48	0.52	0.43	0.43	0.38
24-25	0.42	0.58	0.37	0.54	0.21	0.35	0.21	0.33	0.35	0.51	0.46	0.65	0.37	0.58	0.31	0.50
25-26	0.68	0.77	0.64	0.75	0.44	0.51	0.42	0.51	0.61	0.74	0.74	0.88	0.74	0.89	0.64	0.81
Average	0.49	0.58	0.42	0.49	0.26	0.31	0.24	0.29	0.44	0.52	0.54	0.63	0.52	0.61	0.41	0.49

TABLE 5-21

SOILING PARTICULATE INDEX, COH PER 1000 LINEAL FEET - WINTER SEASON

	100 Constitution Plaza								250 Constitution Plaza							
	Far Outside		Near Outside		Near Inside		Far Inside		Far Outside		Near Outside		Near Inside		Far Inside	
1970	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day
30-31 Jan.	0.26	0.34		0.30	0.30	0.24	0.30	0.24	0.42	0.55		0.43	0.19	0.27	0.19	0.27
31-1 Feb.	0.42	0.50	0.45	0.48	0.40	0.48	0.38	0.46	0.67	0.71	0.66	0.70	0.41	0.48	0.36	0.41
1-2	0.40	0.30	0.41	0.34	0.35	0.27	0.38	0.25	0.57	0.61	0.58	0.47	0.40	0.36	0.36	0.29
2-3	0.22	0.52	0.26	0.55	0.21	0.45	0.22	0.42	0.37	1.00	0.35	0.89	0.26	0.60	0.20	0.54
3-4	0.23	0.24	0.40	0.33	0.28	0.25	0.17	0.13	0.49	0.42	0.31	0.40	0.21	0.32	0.16	0.28
4-5	0.33	0.45	0.41	0.55	0.29	0.40	0.11		0.55	0.76	0.59	0.72	0.27	0.45	0.21	
5-6	0.51	0.58	0.62	0.72	0.63	0.64		0.57	0.89	0.97	0.79	0.90	0.53	0.57		0.65
6-7	0.64	0.52	0.76	0.61	0.79	0.45	0.59	0.36	1.09	0.84	1.05	0.83	0.54	0.45	0.60	0.46
7-8 (Sun)	0.60	0.54	0.71	0.65	0.68	0.68	0.54	0.56	0.97	0.92	0.93	0.88	0.66	0.79	0.63	0.66
8-9	0.61	0.50	0.71	0.59	0.69	0.51	0.57	0.43	0.99	0.90	0.97	0.81	0.82	0.61	0.69	0.56
9-10	0.28	0.25	0.34	0.31	0.33	0.27	0.30	0.25	0.55	0.47	0.52	0.47	0.41	0.31	0.33	0.30
10-11	0.26	0.44	0.30	0.52	0.31	0.34	0.23	0.35	0.50	0.80	0.44	0.76	0.37	0.51	0.30	0.40
11-12	0.28	0.33	0.36	0.40	0.28	0.24	0.30	0.25	0.41	0.59	0.41	0.52	0.31	0.34	0.24	0.31
12-13	0.32	0.35	0.40	0.48	0.31	0.27	0.31	0.29	0.48	0.63	0.45	0.56	0.35	0.38	0.30	0.32
Average	0.38	0.41	0.47	0.49	0.42	0.39	0.34	0.35	0.64	0.72	0.62	0.67	0.41	0.45	0.35	0.42

TABLE 5-22

SOILING PARTICULATE INDEX, COH PER 1000 LINEAL FEET - WINTER SEASON

	Blinn Street								Carroll Road							
	Far Outside		Near Outside		Near Inside		Far Inside		Far Outside		Near Outside		Near Inside		Far Inside	
1970	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day
26-27 Feb.	0.66	0.39	0.59	0.38	0.47	0.28	0.38	0.26	0.62	0.39	0.59	0.39	0.41	0.25	0.41	0.29
27-28	0.42	0.36	0.41	0.42	0.30	0.31	0.28	0.31	0.28	0.26	0.28	0.27	0.16	0.18	0.20	0.23
28-1 March	0.36	0.37	0.37	0.37	0.27	0.34	0.26	0.32	0.28	0.31	0.28	0.31	0.18	0.21	0.22	0.25
1-2	0.48	0.60	0.51	0.60	0.35	0.47	0.36	0.43	0.47	0.47	0.48	0.52	0.32	0.38	0.39	0.45
2-3	0.76	0.60	0.75	0.62	0.53	0.50	0.54	0.49	0.44	0.39	0.48	0.40	0.32	0.30	0.42	0.39
3-4	0.97	0.50	1.04	0.53	0.84	0.43	0.60	0.44	0.80	0.44	0.81	0.46	0.60	0.33	0.74	0.39
4-5	0.41	0.60	0.45	0.61	0.33	0.50	0.32	0.49	0.32	0.38	0.34	0.40	0.23	0.28	0.27	0.36
5-6	0.51	0.43	0.53	0.45	0.41	0.35	0.41	0.35	0.31	0.26	0.32	0.25	0.24	0.20	0.30	0.25
6-7	0.56	0.37	0.54	0.37	0.39		0.43	0.32	0.31	0.34	0.30	0.35	0.19	0.30	0.30	0.32
7-8 (Sun)	0.44	0.16	0.42	0.17		0.12	0.35	0.16	0.45	0.11	0.44	0.11	0.32	0.11	0.39	0.15
8-9	0.25	0.29	0.24	0.28	0.19	0.26	0.20	0.26	0.13	0.16	0.12	0.18	0.07	0.11	0.10	0.15
9-10	0.34	0.28	0.35	0.28	0.27	0.28	0.28	0.25	0.16	0.18	0.16	0.20	0.12	0.13	0.14	0.17
10-11	0.38	0.28	0.36	0.30	0.26	0.18	0.27	0.23	0.21	0.19	0.22	0.19	0.15	0.14	0.18	0.17
11-12	0.40	0.31	0.41	0.29	0.32	0.26	0.32	0.26	0.25	0.21	0.28	0.20	0.19	0.17	0.22	0.18
Averages	0.50	0.40	0.50	0.41	0.38	0.33	0.37	0.33	0.36	0.29	0.36	0.30	0.25	0.22	0.30	0.27

5-23

FAR INSIDE/FAR OUTSIDE RATIOS FOR SOILING PARTICULATE - SUMMER SEASON

1969	Public Library		City Hall		1969	100 Const. Pl.		250 Const. Pl.		1969	Blinn St.		Carroll Rd.	
	Night	Day	Night	Day		Night	Day	Night	Day		Night	Day	Night	Day
21-22 July	0.87	0.88	0.91	1.06	21-22 Aug.	0.86	1.01	0.62	0.57	10-11 Sep.	0.89	0.82		
22-23	0.92	0.82	1.05	1.04	22-23	0.93	0.53	0.75	0.37	11-12	0.69	0.80		
23-24	0.81	0.98	0.95	1.14	23-24 (Sun)	0.72	1.51	0.64	0.51	12-13	0.66	0.74		
24-25	0.83	0.85	0.89	1.07	24-25	0.61	0.97	0.73	0.43	13-14 (Sun)	0.71	0.76		
25-26	0.93	0.99		0.87	25-26	0.95	1.00	0.48	0.52	14-15	0.74	0.77		
26-27 (Sun)	0.99	0.73	0.68	0.90	26-27			0.45	0.51	15-16	0.90	0.74	1.17	1.07
27-28	0.95	1.02	0.79	0.95	27-28		0.69	0.52	0.49	16-17	0.80	0.82	1.09	1.13
28-29	0.70	0.72	1.10	0.94	28-29	0.80	0.80	0.53	0.49	17-18	0.81	0.79	1.06	1.07
29-30	0.86	0.92	0.99	1.02	29-30	0.74	0.57	0.53	0.48	18-19	0.73	0.78	0.96	1.09
30-31	0.82	0.80	1.14	0.94	30-31 (Sun)	0.90	1.16	0.45	0.80	19-20	0.66	0.78	0.84	1.12
31-1 Aug.	0.90	0.87	1.00	0.92	31-1 Sept.	0.88	1.33	0.79	0.86	20-21 (Sun)	0.81	0.93	1.03	1.20
1-2	0.85	1.02	1.11	1.06	1-2	0.89	0.72	0.77	0.53	21-22	0.85	0.90	1.11	1.09
2-3 (Sun)	0.91	0.79	1.10	1.11	2-3	0.92	0.82	0.57	0.60	22-23	0.93	0.95	1.02	1.03
3-4	0.69	0.82	1.02	1.05	3-4	0.87	0.80	0.56	0.64	23-24	1.00	0.99	0.95	1.12
4-5	0.79	0.67	1.17	1.00						24-25	0.98	0.99	1.35	2.05
5-6	0.76	0.79	1.02	1.01						25-26	1.00	1.04	0.94	1.09
6-7	0.72	0.78	0.96	1.06						26-27	0.97	1.01	1.15	1.05
7-8	0.74	0.74	0.95	0.84						27-28 (Sun)	1.15	1.53	1.32	0.84
										28-29	0.96	1.08	1.11	1.20
										29-30	0.90		1.09	
Ratio of Averages	0.81	0.81	1.00	0.98		0.83	0.87	0.62	0.57		0.85	0.89	1.10	1.19

TABLE 5-24

FAR INSIDE/FAR OUTSIDE RATIOS FOR SOILING PARTICULATE - FALL SEASON

1969	Public Library		City Hall		1969	100 Const. Pl.		20 Const. Pl.		1969	Blinn St.		Carroll Rd.	
	Night	Day	Night	Day		Night	Day	Night	Day		Night	Day	Night	Day
9-10 Oct.	1.06	0.98		1.32	31-1 Nov.	0.79	0.45	0.88	0.71	19-20 Nov.	0.94	0.97	0.86	0.64
10-11	0.97	0.94	1.03	0.96	1-2 (Sun)	1.00	0.73	0.79	0.93	20-21	0.90	0.92	0.72	0.82
11-12 (Sun)	1.01	0.89	1.03	0.97	2-3	0.90	0.98	0.98	0.70	21-22	0.87	0.89	0.72	0.76
12-13	0.98	0.88	0.80	0.94	3-4	0.88	0.75	0.80	0.75	22-23 (Sun)	0.80	0.86	0.63	0.65
13-14	0.96	1.03	0.96	1.11	4-5	0.84	0.89	0.72	0.78	23-24	0.92	0.92	0.71	0.79
14-15	0.92	0.84	0.95	1.23	5-6	0.65	0.69	0.74	0.88	24-25	0.91	1.08	0.52	0.71
15-16	0.93	1.00	1.12	1.30	6-7	0.61	0.70	0.72	0.89	25-26	0.90	0.88	0.67	0.78
16-17	0.87	1.00	0.97	1.32	7-8	0.87	0.48	0.74	0.66	26-27	0.89	0.93	0.63	0.92
17-18	0.91	1.01	1.18	1.12	8-9 (Sun)	0.55	0.73	0.86	0.85	27-28	0.84	0.89	0.56	0.89
18-19 (Sun)	0.96	0.94	1.22	0.45	9-10	0.49	0.81	0.76	0.94	28-29	0.92	0.90	0.64	0.69
19-20		0.76	0.92	1.26	10-11	0.68	0.71	1.02	1.02	29-30 (Sun)	0.84	0.99	0.80	1.04
20-21	0.87	0.83	1.10	1.05	11-12	0.69	0.58	0.82	0.71	30-1 Dec.	0.76	0.86	0.66	0.74
21-22	0.85	0.86	1.18	1.28	12-13	0.91	0.71	0.96	0.64	1-2	0.71	0.81	0.86	1.38
22-23	0.83	0.79	1.13	1.21	13-14	0.80	0.69	0.87	1.00	2-3			0.62	0.73
Ratio of Averages	0.94	0.92	1.14	1.15		0.79	0.69	0.84	0.79		0.89	0.88	0.67	0.80

TABLE 5-25

FAR INSIDE/FAR OUTSIDE RATIOS FOR SOILING PARTICULATE - WINTER SEASON

1970	Public Library		City Hall		1970	100 Const. Pl.		250 Const. Pl.		1970	Blinn St.		Carroll Rd.	
	Night	Day	Night	Day		Night	Day	Night	Day		Night	Day	Night	Day
12-13 Jan.	0.46	0.53	0.82	0.86	30-31 Jan.	1.14	0.72	0.45	0.49	26-27 Feb.	0.57	0.67	0.67	0.73
13-14	0.47	0.36	0.91	0.85	31-1 Feb.	0.91	0.92	0.54	0 58	27-28	0.67	0.86	0.71	0.90
14-15	0.43	0.38	0.85	0.78	1-2	0.96	0.85	0.63	0.48	28-1 Mar.	0.73	0.87	0.78	0.82
15-16	0.41	0.46	0.83	0.93	2-3	0.97	0.80	0.54	0.54	1-2	0.74	0.72	0.84	0.95
16-17	0.54	0.52	0.97	0.85	3-4	0.73	0.56	0.32	0.65	2-3	0.70	0.82	0.97	1.00
17-18 (Sun)	0.59	0.51	0.92	1.08	4-5	0.33		0.38		3-4	0.82	0.89	0.93	0.89
18-19	0.37	0.41	0.92	0.97	5-6		0.98		0.67	4-5	0.77	0.82	0.83	0.95
19-20	0.45	0.51	0.82	0.93	6-7	0.92	0.69	0.55	0.55	5-6	0.80	0.82	0.97	0.97
20-21	0.52	0.44	1.02	0.94	7-8 (Sun)	0.89	1.03	0.65	0.71	6-7	0.76	0.88	0.98	0.92
21-22	0.40	0.39	0.98	0.86	8-9	0.94	0.86	0.69	0.62	7-8 (Sun)	0.80	0.99	0.85	1.35
22-23	0.43	0.56	1.00	1.00	9-10	1.06	1.01	0.60	0.65	8-9	0.81	0.88	0.85	0.94
23-24	0.52	0.49	0.95	0.97	10-11	0.86	0.80	0.60	0.50	9-10	0.81	0.87	0.90	0.95
24-25 (Sun)	0.49	0.57	0.90	0.99	11-12	1.05	0.76	0.60	0.52	10-11	0.73	0.82	0.85	0.88
25-26	0.62	0.66	1.05	1.10	12-13	0.99	0.82	0.63	0.51	11-12	0.79	0.86	0.86	0.86
Ratio of Averages	0.49	0.50	0.93	0.94		0.89	0.85	0.55	0.58		0.74	0.82	0.83	0.93

TABLE 5-26

DAY/NIGHT RATIOS FOR SOILING PARTICULATE - SUMMER SEASON

1969	Public Library				City Hall			
	Far Outside	Near Outside	Near Inside	Far Inside	Far Outside	Near Outside	Near Inside	Far Inside
22-23 July	1.56	1.57	1.52	1.50	1.50	1.58	1.50	1.51
23-24	0.98	0.82	1.03	0.98	1.08	0.90	1.12	1.18
24-25	1.02	0.96	1.04	1.21	0.96		1.12	1.23
25-26	2.09	2.10	2.29	1.91				
26-27 (Sun)	2.79	2.39	2.81	2.80	2.25	3.34	3.04	2.86
27-28	1.27	0.98	1.10	0.99	1.11	1.42	1.27	1.26
28-29	1.71	1.44	1.71	2.50	2.06	1.82	1.81	1.78
29-30	1.39	1.20	1.18	1.16	1.37	1.29	1.39	1.29
30-31	1.05	0.99	1.11	1.17	1.37	1.18	1.17	1.21
31-1 Aug.	0.95	0.85	0.89	0.84	1.06	0.95	0.99	1.00
1-2	2.14	2.21	2.24	2.17	2.59	2.36	2.27	2.15
2-3 (Sun)	1.63	1.60	1.63	1.82	1.55	1.47	1.54	1.50
3-4	0.99	1.04	1.10	1.13	0.93	0.93	1.07	1.01
4-5	1.76	1.63	1.69	1.83	1.86	1.71	1.76	1.67
5-6	1.34	1.29	1.13	1.19	1.47	1.39	1.48	1.43
6-7	0.85	0.89	0.93	0.95	0.95	0.87	1.07	1.02
7-8	0.99	0.97	1.00	1.05	0.82	0.81	0.90	0.92
Ratio of Averages	1.35	1.27	1.36	1.36	1.37	1.35	1.39	1.33

TABLE 5-27

DAY/NIGHT RATIOS FOR SOILING PARTICULATE - SUMMER SEASON

	100 Constitution Plaza				250 Constitution Plaza			
1969	Far Outside	Near Outside	Near Inside	Far Inside	Far Outside	Near Outside	Near Inside	Far Inside
22-23 Aug.	0.48		0.46	0.52	0.56	0.53	0.41	0.43
23-24 (Sun)	0.96		0.65	0.70	0.89	0.91	0.60	0.52
24-25	0.34		0.76	0.84	0.40	0.41	0.32	0.28
25-26	1.26	0.97	1.29	1.29	1.40	1.29	1.20	1.23
26-27					1.35	1.33	1.53	1.56
27-28					0.69	0.73	0.74	0.69
28-29	1.12	1.25	1.01	0.98	1.26	1.17	1.10	1.16
29-30	0.77	0.86	0.79	0.83	0.82	0.70	0.74	0.75
30-31 (Sun)	1.67	1.57	1.03	1.07	1.58	1.53	1.36	1.68
31-1 Sept.	0.77	0.77	0.95	1.01	0.83	0.86	0.85	0.84
1-2	0.60	0.62	0.84	0.89	0.63	0.63	0.75	0.71
2-3	1.45	1.48	1.11	1.14	1.47	1.54	1.41	1.38
3-4	0.96	0.98	0.98	0.91	1.04	1.08	1.15	1.11
Ratio of Averages	0.83	1.00	0.87	0.87	0.88	0.89	0.82	0.81

TABLE 5-28

DAY/NIGHT RATIOS FOR SOILING PARTICULATE - SUMMER SEASON

1969	Blinn Street				Carroll Road			
	Far Outside	Near Outside	Near Inside	Far Inside	Far Outside	Near Outside	Near Inside	Far Inside
10-11 Sept.	0.43	0.36	0.37	0.40				
11-12	0.61	0.54	0.69	0.73				
12-13	0.88	0.94	0.98	1.07				
13-14 (Sun)	0.67	0.67	0.69	0.71				
14-15	1.50	1.59	1.43	1.54				
15-16	0.94	0.88	0.86	0.80	0.76	0.73	0.77	0.83
16-17	1.06	1.00	0.99	0.99	1.05	0.99	1.05	1.03
17-18	1.51	1.69	1.59	1.53	3.65	3.68	3.82	3.89
18-19	0.70	0.67	0.78	0.76	0.67	0.66	0.63	0.74
19-20	0.81	0.87	0.85	0.96	0.50	0.59	0.60	0.66
20-21 (Sun)	1.23	0.98	1.10	1.19	0.83	0.79	0.96	0.91
21-22	0.46	0.45	0.49	0.50	0.55	0.56	0.58	0.60
22-23	0.78	0.82	0.78	0.76	0.65	0.68	0.73	0.70
23-24	0.67	0.68	0.66	0.64	0.70	0.74	0.72	0.75
24-25	0.73	0.74	0.73	0.74	0.85	0.81	0.82	0,71
25-26	1.48	1.45	1.40	1.47	2.02	1.99	2.20	4.42
26-27	1.22	1.24	1.27	1.30	1.32	1.33	1.30	1.26
27-28 (Sun)	1.23	1.15	1.24	1.08	1.23	1.28	1.30	0.97
28-29	0.32	0.35	0.38	0.51	0.37	0.39	0.52	0.28
29-30	0.53	0.53	0.63	0.64	0.29	0.27	0.34	0.32
Ratio of Averages	0.83	0.81	0.85	0.87	0.84	0.87	0.89	0.90

TABLE 5-29

DAY/NIGHT RATIOS FOR SOILING PARTICULATE - FALL SEASON

1969	Public Library				City Hall			
	Far Outside	Near Outside	Near Inside	Far Inside	Far Outside	Near Outside	Near Inside	Far Inside
9-10 Aug.	0.53	0.34	0.40	0.43				
10-11	1.09	1.20	1.03	1.10	0.92	1.04	1.15	1.18
11-12	1.19	1.22	1.15	1.11	1.31	1.22	1.28	1.23
12-13	0.78	0.70	0.69	0.71	0.64	0.63	0.74	0.77
13-14	1.47	1.33	1.39	1.34	1.33	1.35	1.25	1.31
14-15	1.78	1.73	2.00	2.00	1.85	1.73	2.14	2.15
15-16	0.64	0.55	0.63	0.58	0.54	0.49	0.56	0.60
16-17 (Sun)	0.96	0.91	1.09	1.11	0.99	0.95	1.29	1.32
17-18	2.22	2.06	2.32	2.45	2.47	2.25	2.61	2.76
18-19	0.97	1.03	0.95	1.02	0.96	0.88	1.02	0.89
19-20	0.74	0.78	0.69		0.67	0.82	0.67	0.33
20-21	1.65	1.60	1.61	1.43	1.52	1.75	1.87	1.73
21-22	1.29	1.31	1.34	1.27	1.45	1.37	1.34	1.30
22-23	2.17	2.01	2.21	2.28	2.05	2.07	2.26	2.33
Ratio of Averages	1.06	1.03	1.03	1.03	1.14	1.03	1.13	1.15

TABLE 5-30

DAY/NIGHT RATIOS FOR SOILING PARTICULATE - FALL SEASON

1969	100 Constitution Plaza				250 Constititution Plaza			
	Far Outside	Near Outside	Near Inside	Far Inside	Far Outside	Near Outside	Near Inside	Far Inside
31-1 Nov.	0.77	0.82	0.75	0.86	0.86	0.74	0.69	0.59
1-2 (Sun)	1.00	1.02	0.71	0.45	0.91	0.90	0.88	0.82
2-3	1.50	1.36	1.37	1.21	1.59	1.38	1.76	1.50
3-4	0.61	0.65	0.62	0.69	0.65	0.68	0.55	0.57
4-5	1.57	1.52	1.31	1.41	1.54	1.49	1.80	1.61
5-6	1.19	1.25	1.58	1.62	1.74	1.63	1.90	1.82
6-7	1.47	1.46	1.42	1.66	1.32	1.16	1.34	1.61
7-8	1.28	1.20	0.99	1.02	1.21	1.21	1.49	1.45
8-9 (Sun)	1.20	1.12	1.01	1.04	1.19	1.12	0.81	0.91
9-10	1.44	1.49	1.62	2.14	1.06	1.02	1.43	1.18
10-11	1.48	1.54	1.49	1.75	1.72	1.55	1.76	1.59
11-12	0.80	2.31	0.89	0.83	0.69	0.90	0.86	0.87
12-13	1.64	1.61	1.09	1.05	1.51	1.47	1.14	1.13
13-14	0.61	0.69	0.60	0.54	0.84	0.74	0.59	0.62
Ratio of Averages	1.12	1.21	0.96	1.00	1.12	1.08	1.04	1.05

TABLE 5-31

DAY/NIGHT RATIOS FOR SOILING PARTICULATE - FALL SEASON

1969	Blinn Street				Carroll Road			
	Far Outside	Near Outside	Near Inside	Far Inside	Far Outside	Near Outside	Near Inside	Far Inside
19-20 Nov.	1.46	1.28	1.56	1.49	2.01	1.85	1.88	1.66
20-21	0.88	0.98	1.01	0.95	0.87	0.80	0.83	0.77
21-22	0.84	0.90	0.90	0.90	1.09	0.87	1.26	1.24
22-23 (Sun)	0.83	0.88	0.86	0.91	0.87	0.76	1.03	1.04
23-24	1.14	1.08	1.07	1.06	1.18	1.31	1.06	1.07
24-25	0.59	0.55	0.56	0.60	0.47	0.36	0.79	0.71
25-26	0.92	1.06	1.22	1.11	0.92	0.84	0.94	0.98
26-27	1.08	1.11	1.18	1.08	1.11	1.15	1.39	1.37
27-28	0.34	0.35	0.35	0.37	0.48	0.48	0.73	0.78
28-29	0.72	0.68	0.71	0.70	0.69	0.76	0.94	0.96
29-30 (Sun)	1.24	1.29	1.31	1.33	1.39	1.46	1.20	1.19
30-1 Dec.	0.79	0.83	0.97	1.02	0.67	0.57	0.95	1.06
1-2	1.67	1.91	2.23	2.01	2.14	2.34	1.82	1.86
2-3	0.94	1.01	0.93		0.49	0.48	1.00	1.08
Ratio of Averages	0.94	0.95	1.00	0.97	0.94	0.92	1.13	1.08

TABLE 5-32

DAY/NIGHT RATIOS FOR SOILING PARTICULATE - WINTER SEASON

1970	Public Library				City Hall			
	Far Outside	Near Outside	Near Inside	Far Inside	Far Outside	Near Outside	Near Inside	Far Inside
12-13 Jan.	0.87	0.90	0.97	0.97	0.97	0.96	1.07	0.98
13-14	2.13	2.50	2.29	2.41	2.43	2.14	2.15	2.31
14-15	1.71	1.32	1.58	1.45	1.69	1.57	1.61	1.68
15-16	0.87	0.87	0.79	0.82	0.92	0.82	0.83	0.87
16-17	1.08	1.02	0.96	0.92	1.07	1.05	1.00	1.02
17-18 (Sun)	1.04	0.95	0.90	0.93	0.94	0.98	0.90	0.87
18-19	1.13	1.19	1.59	1.58	1.20	1.14	1.48	1.42
19-20	1.08	0.86	0.97	0.97	0.85	0.95	1.00	1.02
20-21	1.62	1.59	1.55	1.58	1.79	1.59	1.68	1.64
21-22	1.64	1.69	2.04	1.79	2.14	1.81	2.08	2.06
22-23	0.85	0.86	0.75	0.77	0.90	0.79	0.80	0.78
23-24	1.51	1.46	1.44	1.61	1.42	1.46	1.50	1.51
24-25 (Sun)	1.18	1.08	1.15	1.18	1.13	1.04	1.15	1.22
25-26	0.86	0.84	0.79	0.79	0.83	0.88	0.79	0.78
Ratio of Averages	1.18	1.17	1.19	1.21	1.18	1.17	1.17	1.19

TABLE 5-33

DAY/NIGHT RATIOS FOR SOILING PARTICULATE - WINTER SEASON

1970	100 Constitution Plaza				250 Constitution Plaza			
	Far Outside	Near Outside	Near Inside	Far Inside	Far Outside	Near Outside	Near Inside	Far Inside
30-31 Jan.	0.85		0.90	0.94	0.92		1.15	1.20
31-1 Feb.	0.80	0.67	0.61	0.63	0.82	0.64	0.64	0.76
1-2	1.26	1.15	1.36	1.21	1.24	1.20	1.21	1.14
2-3	1.34	1.28	1.25	1.17	1.65	1.37	1.43	1.48
3-4	2.22	1.38	1.59	2.43	2.05	2.91	2.86	3.48
4-5	0.71	0.81	0.88	1.19	0.78	0.68	1.20	1.35
5-6	0.87	0.88	0.62		0.86	0.91	0.85	
6-7	0.91	0.95	0.81	0.97	0.89	0.85	1.05	1.07
7-8 (Sun)	0.87	0.85	0.65	0.68	0.87	0.90	0.69	0.73
8-9	0.89	0.91	0.98	0.98	0.93	0.91	0.95	0.96
9-10	1.79	1.74	1.54	1.45	1.62	1.56	1.49	1.70
10-11	0.94	1.04	0.87	1.10	0.95	1.07	0.82	1.02
11-12	1.54	1.45	1.21	1.18	1.99	1.87	1.66	1.63
12-13	1.04	0.98	0.78	0.79	1.23	1.17	0.96	1.01
Ratio of Averages	1.08	1.04	0.93	1.03	1.12	1.08	1.10	1.20

TABLE 5-34

DAY/NIGHT RATIOS FOR SOILING PARTICULATE - WINTER SEASON

1970	Blinn Street				Carroll Road			
	Far Outside	Near Outside	Near Inside	Far Inside	Far Outside	Near Outside	Near Inside	Far Inside
26-27 Feb.	0.51	0.47	0.62	0.55	0.31	0.31	0.43	0.34
27-28	0.93	0.92	0.94	0.93	1.38	1.40	1.57	1.42
28-1 Mar.	1.01	1.16	1.15	1.19	0.90	0.96	0.97	1.04
1-2	0.77	0.73	0.98	0.90	0.66	0.64	0.65	0.65
2-3	0.78	0.80	0.89	0.81	1.08	1.08	1.17	1.06
3-4	0.62	0.60	0.59	0.62	0.48	0.49	0.51	0.52
4-5	1.20	1.20	1.30	1.38	1.39	1.36	1.47	1.47
5-6	1.17	1.15	1.21	1.21	1.24	1.23	1.18	1.22
6-7	0.78	0.83	0.89	0.83	0.83	0.82	1.02	0.83
7-8 (Sun)	0.84	0.89		0.92	0.76	0.78	0.94	0.82
8-9	0.65	0.70	0.64	0.79	0.97	0.93	1.59	1.52
9-10	0.85	0.82	0.95	0.93	0.98	1.13	0.93	1.03
10-11	0.75	0.78	1.08	0.90	0.89	0.91	0.87	0.98
11-12	0.70	0.72	0.55	0.72	0.76	0.68	0.74	0.78
Ratio of Averages	0.80	0.82	0.87	0.89	0.81	0.83	0.88	0.90

Day/night ratios of soiling indexes are shown by the day for all locations in Tables 5-26 to 5-28 for the summer season, Tables 5-29 to 5-31 for the fall, and Tables 5-32 to 5-34 for the winter season.

5.3 Gaseous Pollutants

The season average concentrations, their day/night ratios by position, and the far inside to far outside ratios by day and night, are presented in the following tables. Carbon monoxide concentrations, as parts per million, are listed for the three seasons, by building pairs, in Tables 5-35 to 5-37. Sulfur dioxide concentrations, as parts per billion, are listed for only fall and winter in Table 5-38 for the public and office buildings for the three seasons in Table 5-39 for the residences. The sulfur dioxide concentrations measured in the summer at the public and office buildings were generally less than the sensitivity of the analyzers as they were performing at the time and the data obtained is essentially valueless and could be misleading.

For both gaseous pollutants, the three five-minute samples each hour were visually averaged and digitized with a semi-automatic reader. Within a computer, the appropriate corrections and scaling were applied individually to the samples and mean values calculated for the two-hour periods corresponding to the soiling index sampling periods. Tables listing these two-hour values and corresponding 12-.and 24-hour mean concentrations are contained in the data supplements. It will be noted that many small values reported for sulfur dioxide are negative, a situation which is normal and arises when

TABLE 5-35

CARBON MONOXIDE - Season Averages and Ratios
(parts per million)

	Library			City Hall		
	Day	Night	Day/Night	Day	Night	Day/Night
SUMMER:						
Far Outside	3.73	2.17	1.72	3.40	1.97	1.73
Near Outside	3.17	2.09	1.52	3.05	1.87	1.63
Near Inside	3.12	2.08	1.50	3.04	2.00	1.52
Far Inside	3.24	2.17	1.49	3.04	2.00	1.52
Far Inside / Far Outside	0.87	1.00		0.89	1.02	
FALL:						
Far Outside	6.14	4.72	1.30	4.90	3.78	1.30
Near Outside	4.86	4.23	1.15	4.43	3.58	1.24
Near Inside	4.67	4.50	1.04	4.38	3.85	1.14
Far Inside	4.76	4.52	1.05	4.35	3.83	1.14
Far Inside / Far Outside	0.78	0.96		0.89	1.01	
WINTER:						
Far Outside	6.32	3.02	2.09	7.50	3.71	2.02
Near Outside	5.20	2.71	1.92	6.44	3.43	1.88
Near Inside	5.22	3.02	1.73	6.02	3.43	1.76
Far Inside	5.28	3.06	1.73	6.02	3.45	1.74
Far Inside / Far Outside	0.84	1.01		0.80	0.93	

TABLE 5-36

CARBON MONOXIDE - Season Averages and Ratios
(parts per million)

	100 Constitution Plaza			250 Constitution Plaza		
	Day	Night	Day/Night	Day	Night	Day/Night
SUMMER:						
Far Outside	2.55	2.80	0.91	3.26	3.11	1.05
Near Outside	2.68	2.90	0.92	3.29	3.18	1.03
Near Inside	3.38	2.80	1.21	3.38	3.04	1.11
Far Inside	3.34	2.81	1.19	3.42	3.18	1.08
Far Inside / Far Outside	1.31	1.00		1.05	1.02	
FALL:						
Far Outside	2.72	1.99	1.37	4.01	2.92	1.37
Near Outside	2.98	2.08	1.43	3.77	2.87	1.31
Near Inside	3.53	2.48	1.42	3.82	3.07	1.24
Far Inside	3.58	2.48	1.44	3.83	3.05	1.26
Far Inside / Far Outside	1.32	1.25		0.96	1.04	
WINTER:						
Far Outside	3.39	2.69	1.26	4.26	2.43	1.75
Near Outside	3.55	2.74	1.30	3.77	2.37	1.59
Near Inside	3.79	3.22	1.18	3.21	2.32	1.38
Far Inside	3.82	3.25	1.18	3.23	2.34	1.38
Far Inside / Far Outside	1.13	1.21		0.76	0.96	

TABLE 5-37

CARBON MONOXIDE - Season Averages and Ratios
(parts per million)

	Blinn St.			Carroll Road		
	Day	Night	Day/Night	Day	Night	Day/Night
SUMMER:						
Far Outside	2.52	3.14	0.80	2.06	2.70	0.76
Near Outside	2.43	3.08	0.79	2.06	2.72	0.76
Near Inside	2.53	3.32	0.76	2.12	2.74	0.77
Far Inside	2.57	3.36	0.76	2.15	2.75	0.78
Far Inside / Far Outside	1.02	1.07		1.04	1.02	
FALL:						
Far Outside	3.06	3.21	0.95	3.33	2.70	1.23
Near Outside	3.08	3.23	0.95	3.16	2.75	1.14
Near Inside	3.11	3.37	0.92	3.33	2.93	1.13
Far Inside	3.17	3.48	0.91	3.20	2.94	1.08
Far Inside / Far Outside	1.03	1.08		0.96	1.08	
WINTER:						
Far Outside	2.05	2.09	0.98	1.84	1.99	0.92
Near Outside	2.15	2.10	0.97	1.86	2.07	0.89
Near Inside	2.15	2.18	0.98	2.02	2.20	0.91
Far Inside	2.21	2.27	0.97	2.07	2.23	0.92
Far Inside / Far Outside	1.07	1.08		1.12	1.12	

TABLE 5-38

SULFUR DIOXIDE - Season Averages and Ratios
(parts per billion)

	LIBRARY			CITY HALL			100 CONSTITUTION PLAZA			250 CONSTITUTION PLAZA		
	Day	Night	Day/Night	Day	Night	Day/Night	Day	Night	Day/Night	Day	Night	Day/Night
FALL:												
Far Outside	4	13	0.31	17	22	0.77	17	18	0.94	3	2	1.5
Near Outside	10	19	0.53	25	24	1.04	23	21	1.10	1	2	0.5
Near Inside	10	22	0.45	24	27	0.89	13	11	1.18	-2	-1	-
Far Inside	12	27	0.44	20	25	0.80	14	10	1.40	-4	-1	-
Far Inside / Far Outside	3.0	2.08		1.18	1.14		0.82	0.56		-	-	
WINTER:												
Far Outside	63	76	0.83	68	71	0.96	52	52	1.00	45	37	1.22
Near Outside	66	78	0.85	72	74	0.97	50	58	0.85	47	41	1.15
Near Inside	61	77	0.79	61	57	1.07	40	43	0.93	39	35	1.11
Far Inside	60	73	0.82	58	56	1.04	39	40	0.98	38	37	1.03
Far Inside / Far Outside	0.95	0.96		0.85	0.79		0.75	0.77		0.84	1.00	

TABLE 5-39

SULFUR DIOXIDE - Season Averages and Ratios
(parts per billion)

	Blinn St.			Carroll Rd.		
	Day	Night	Day/Night	Day	Night	Day/Night
SUMMER:						
Far Outside	6	3	2	0	3	0
Near Outside	9	3	3	8	10	0.8
Near Inside	17	4	4.25	33	26	1.27
Far Inside	15	5	3.0	38	28	1.36
Far Inside / Far Outside	2.5	1.67		—	9.3	
FALL:						
Far Outside	35	40	0.88	22	24	0.92
Near Outside	35	39	0.90	24	24	1.00
Near Inside	23	28	0.82	21	2	10.5
Far Inside	19	25	0.76	20	6	3.3
Far Inside / Far Outside	0.54	0.62		0.91	0.25	
WINTER:						
Far Outside	13	21	0.62	13	17	0.76
Near Outside	13	22	0.59	13	19	0.68
Near Inside	11	16	0.69	8	4	2.0
Far Inside	10	17	0.59	6	1	6.0
Far Inside / Far Outside	0.77	0.81		0.45	0.06	

the reference "scrub" value is greated than the SO_2 reading. Negative values reflect the statistical fluctuations introduced by measurement uncertainities and by fluctuating carbon dioxide background, and must be preserved to maintain the validity of subsequent data averaging computations. A similar problem does not generally arise in the processing of the carbon monoxide data, the fluctuations in the zero reference are much less and these are masked by the existence of a small residual concentration.

The data for carbon monoxide has been further manipulated to display daily time and space ratios. The far inside/far outside ratio concentrations for the three seasons are presented in Tables 5-40 to 5-42. The day/night ratio of concentration at each sampling point has been formed of 12-hour average concentrations from each night and the following day and the date listed is that of the beginning of the night period. These day/night ratios are presented in Tables 5-43 to 5-45, 5-46 to 5-48 and 5-49 to 5-51, respectively, for the summer, fall and winter seasons. Similar tables were generated for time and space ratios of sulfur dioxide concentrations but their contents were disappointing. The frequently low levels of sulfur dioxide and the noise or uncertainty in the analyzer readings compounded to give many wild ratios with the result that these daily tables are of marginal value and are not included in this report. The ratios of seasonal means are, however, much better behaved and are included in Tables 5-38 and 5-39 mentioned earlier.

At the two residences in East Hartford, we calibrated the diffusion characteristics of the buildings through the introduction of suitable quantities of CO tracer gas near the termination of each sampling season. The houses were unoccupied and closed during each

TABLE 5-40

FAR INSIDE/FAR OUTSIDE RATIO FOR CO CONCENTRATIONS - SUMMER SEASON

	PUBLIC LIBRARY		CITY HALL			100 CONST. PL.		250 CONST. PL.			BLINN ST.		CARROLL RD.	
DATE	DAY	NIGHT	DAY	NIGHT	DATE	DAY	NIGHT	DAY	NIGHT	DATE	DAY	NIGHT	DAY	NIGHT
7/21	****	1.01	****	1.04	8/21	****	1.06	****	1.12	9/10	****	1.13	****	****
7/22	0.74	1.04	0.94	1.10	8/22	1.42	0.99	1.19	0.99	9/11	1.03	1.03	****	****
7/23	0.65	0.98	0.91	1.09	8/23	1.08	0.65	0.96	0.75	9/12	1.10	1.11	****	****
7/24	0.88	1.05	1.08	1.04	8/24	****	0.69	****	****	9/13	1.14	0.99	****	****
7/25	0.72	1.16	1.00	1.02	8/25	1.56	1.19	****	1.10	9/14	1.08	1.08	****	****
7/26	0.99	1.05	1.03	0.98	8/26	1.80	****	1.11	1.01	9/15	1.04	1.05	****	1.02
7/27	0.98	1.02	0.84	0.92	8/27	****	****	1.00	0.99	9/16	0.96	1.02	0.98	1.02
7/28	1.00	1.06	0.84	0.85	8/28	****	****	0.91	1.23	9/17	1.03	1.05	1.05	1.06
7/29	0.74	0.97	0.82	1.00	8/29	****	1.00	****	****	9/18	1.14	1.12	1.03	1.09
7/30	0.95	0.94	1.02	1.03	8/30	1.12	****	1.20	1.03	9/19	1.06	1.10	1.02	1.02
7/31	0.94	0.98	0.94	0.98	8/31	1.07	0.95	1.07	0.78	9/20	1.09	1.10	1.10	1.01
8/ 1	0.90	1.02	0.80	0.99	9/ 1	1.26	0.90	****	****	9/21	1.14	1.05	1.31	0.98
8/ 2	0.97	1.07	0.99	1.01	9/ 2	1.24	2.53	1.05	1.05	9/22	1.06	1.07	1.13	1.02
8/ 3	0.98	****	1.04	0.96	9/ 3	****	****	1.09	****	9/23	0.97	1.05	1.03	0.92
8/ 4	1.03	1.09	0.81	1.16						9/24	1.04	1.05	****	****
8/ 5	0.65	0.96	0.87	1.03						9/25	0.98	1.16	****	****
8/ 6	0.98	0.91	0.77	0.99						9/26	0.71	****	****	****
8/ 7	0.85	0.97	1.06	0.95						9/27	1.05	1.08	****	****
8/ 8	1.10	****	0.70	****						9/28	1.09	1.10	1.00	1.15
										9/29	****	****	1.03	1.08
										9/30	****	****	****	****
RATIO OF AVERAGES	0.87	1.00	0.89	1.02		1.31	1.00	1.05	1.02		1.02	1.07	1.04	1.02

TABLE 5-41

FAR INSIDE/FAR OUTSIDE RATIO FOR CO CONCENTRATIONS - FALL SEASON

	CITY HALL		PUBLIC LIBRARY			100 CONS.P.		250 CONS.P.			BLINN ST.		CARROLL ST.	
DATE	DAY	NIGHT	DAY	NIGHT	DATE	DAY	NIGHT	DAY	NIGHT	DATE	DAY	NIGHT	DAY	NIGHT
10/ 9	*****	0.98	*****	1.01	10/31	*****	*****	*****	0.93	11/19	*****	*****	*****	1.31
10/10	0.81	0.92	0.94	1.02	11/ 1	1.21	0.99	1.13	1.02	11/20	*****	*****	1.06	1.04
10/11	0.77	1.06	0.84	0.81	11/ 2	1.00	0.99	0.99	1.02	11/21	0.92	*****	1.12	1.28
10/12	0.81	0.87	0.73	0.95	11/ 3	1.42	1.23	0.93	0.93	11/22	1.06	1.05	1.09	1.14
10/13	1.01	1.23	0.73	*****	11/ 4	1.19	1.46	1.09	1.22	11/23	1.05	1.10	1.11	1.17
10/14	0.78	1.07	0.79	*****	11/ 5	1.52	1.23	*****	*****	11/24	1.05	0.96	1.16	1.06
10/15	0.99	0.96	0.71	0.92	11/ 6	1.24	1.48	0.98	0.82	11/25	1.06	1.09	1.06	1.06
10/16	1.04	0.98	0.80	0.90	11/ 7	1.67	1.46	0.99	1.20	11/26	0.99	1.07	1.05	1.14
10/17	1.02	1.17	0.71	0.93	11/ 8	1.28	1.19	0.88	1.25	11/27	1.07	1.08	1.49	0.97
10/18	1.12	1.15	0.81	1.02	11/ 9	1.09	*****	1.05	1.15	11/28	1.03	1.01	1.06	0.88
10/19	0.98	1.07	0.82	1.00	11/10	1.55	1.21	1.11	1.39	11/29	0.97	1.14	0.98	1.26
10/20	0.89	1.11	0.75	0.98	11/11	1.47	1.18	1.12	0.90	11/30	1.61	1.63	1.21	1.15
10/21	0.76	1.18	0.72	1.00	11/12	1.14	1.31	1.07	1.09	12/ 1	1.04	1.15	1.01	1.50
10/22	0.90	0.98	0.83	1.03	11/13	1.19	1.16	0.54	1.02	12/ 2	1.08	1.21	1.43	1.05
10/23	0.80	*****	0.72	*****	11/14	1.45	*****	0.86	*****	12/ 3	1.03	*****	0.38	*****
RATIO OF AVERAGES	0.89	1.01	0.78	0.96		1.32	1.25	0.96	1.04		1.03	1.08	0.96	1.08

TABLE 5-42

FAR INSIDE/FAR OUTSIDE RATIO FOR CO CONCENTRATIONS - WINTER SEASON

DATE	CITY HALL DAY	CITY HALL NIGHT	PUBLIC LIBRARY DAY	PUBLIC LIBRARY NIGHT	DATE	100 CONS.P. DAY	100 CONS.P. NIGHT	250 CONS.P. DAY	250 CONS.P. NIGHT	DATE	BLINN ST. DAY	BLINN ST. NIGHT	CARROLL ST. DAY	CARROLL ST. NIGHT
1/12	*****	0.72	*****	1.00	1/30	*****	1.31	*****	0.97	2/26	*****	1.08	*****	1.07
1/13	0.66	0.90	0.83	1.04	1/31	1.12	1.14	0.55	1.10	2/27	1.06	1.17	1.13	1.20
1/14	0.74	0.77	0.70	0.99	2/ 1	1.04	1.08	0.95	1.19	2/28	1.25	*****	1.23	1.13
1/15	0.68	0.99	0.83	0.99	2/ 2	1.23	1.41	0.47	0.89	3/ 1	1.34	1.04	1.05	1.12
1/16	0.83	1.10	0.86	1.12	2/ 3	1.04	1.27	0.60	1.14	3/ 2	1.00	1.08	1.06	1.17
1/17	0.81	0.86	0.90	0.96	2/ 4	1.35	1.18	1.15	0.87	3/ 3	0.96	1.02	1.12	1.04
1/18	1.01	1.02	0.79	0.91	2/ 5	1.23	1.38	1.13	0.97	3/ 4	1.12	1.18	1.17	1.26
1/19	0.96	0.97	0.97	1.06	2/ 6	1.10	1.19	0.96	0.86	3/ 5	1.04	1.16	1.03	1.22
1/20	0.84	1.15	0.89	1.00	2/ 7	1.11	1.08	0.84	1.04	3/ 6	1.04	1.04	1.11	*****
1/21	0.78	0.93	0.78	0.99	2/ 8	1.07	1.01	0.97	1.03	3/ 7	1.12	1.14	1.16	1.07
1/22	0.76	0.99	0.71	1.01	2/ 9	1.04	1.53	0.83	1.07	3/ 8	1.27	*****	1.31	1.11
1/23	0.85	0.96	0.83	1.07	2/10	1.13	1.29	0.97	0.74	3/ 9	1.09	1.11	1.14	1.21
1/24	0.89	0.98	*****	*****	2/11	1.09	1.31	0.43	1.00	3/10	1.02	1.13	1.08	1.17
1/25	0.93	0.98	0.85	1.04	2/12	1.16	1.46	0.67	0.92	3/11	0.99	1.16	1.15	1.17
1/26	0.89	*****	0.86	*****	2/13	1.34	*****	0.80	*****	3/12	1.06	*****	1.21	*****
RATIO OF AVERAGES	0.83	0.93	0.84	1.01		1.13	1.21	0.76	0.96		1.07	1.08	1.12	1.12

TABLE 5-43

DAY/NIGHT RATIO FOR CO CONCENTRATIONS - SUMMER SEASON

DATE	PUBLIC LIBRARY				CITY HALL			
	FAR OUTSIDE	NEAR OUTSIDE	NEAR INSIDE	FAR INSIDE	FAR OUTSIDE	NEAR OUTSIDE	NEAR INSIDE	FAR INSIDE
7/21	2.47	1.93	1.91	1.82	1.95	1.73	1.77	1.76
7/22	2.16	1.55	1.40	1.35	1.81	1.55	1.51	1.50
7/23	1.41	1.35	1.23	1.26	0.90	0.80	0.86	0.90
7/24	1.47	1.49	1.11	1.01	1.35	1.23	1.28	1.30
7/25	1.45	1.21	1.44	1.25	1.45	1.33	1.37	1.47
7/26	1.55	1.57	1.40	1.45	1.77	1.57	1.44	1.51
7/27	2.34	1.92	2.18	2.30	2.42	2.31	2.15	2.21
7/28	3.42	2.69	2.58	2.39	4.20	4.05	4.41	4.09
7/29	2.76	2.63	2.58	2.71	2.36	2.79	2.43	2.41
7/30	1.25	1.16	1.20	1.26	1.44	1.44	1.33	1.32
7/31	1.21	0.93	1.13	1.12	1.10	1.10	0.92	0.89
8/ 1	1.19	1.27	1.19	1.13	2.00	2.37	1.99	2.01
8/ 2	1.31	1.27	1.26	1.19	1.08	1.10	1.09	1.11
8/ 3	*****	*****	*****	*****	2.45	2.35	2.08	2.08
8/ 4	3.11	2.63	1.93	1.86	2.35	2.05	1.77	1.77
8/ 5	1.35	1.22	1.22	1.39	1.96	1.87	1.45	1.47
8/ 6	1.10	0.99	0.96	1.02	0.84	0.92	0.92	0.90
8/ 7	1.70	1.74	2.09	1.94	2.04	1.87	1.52	1.51
RATIO OF AVERAGES	1.72	1.52	1.50	1.49	1.73	1.63	1.52	1.52

TABLE 5-44

DAY/NIGHT RATIO FOR CO CONCENTRATIONS - SUMMER SEASON

DATE	100 CONS. PLAZA				250 CONS. PLAZA			
	FAR OUTSIDE	NEAR OUTSIDE	NEAR INSIDE	FAR INSIDE	FAR OUTSIDE	NEAR OUTSIDE	NEAR INSIDE	FAR INSIDE
8/21	1.40	1.54	1.84	1.87	0.90	0.87	0.95	0.95
8/22	0.92	0.94	1.01	1.01	0.65	0.66	0.63	0.63
8/23	*****	*****	*****	*****	*****	*****	*****	*****
8/24	0.55	0.62	1.27	1.25	*****	*****	*****	*****
8/25	0.88	1.00	1.16	1.16	1.20	1.23	1.23	1.20
8/26	*****	*****	*****	*****	1.63	1.65	1.92	1.62
8/27	*****	*****	*****	*****	1.66	1.92	1.61	1.52
8/28	*****	*****	*****	*****	*****	*****	*****	*****
8/29	0.42	*****	0.76	0.73	*****	*****	*****	*****
8/30	*****	*****	*****	*****	0.86	0.86	0.86	0.89
8/31	0.78	0.79	1.01	1.03	*****	*****	*****	*****
9/ 1	1.24	1.16	1.73	1.71	*****	*****	*****	*****
9/ 2	*****	*****	*****	*****	1.73	1.86	1.75	1.79
RATIO OF AVERAGES	0.91	0.92	1.21	1.19	1.05	1.03	1.11	1.08

TABLE 5-45

DAY/NIGHT RATIO FOR CO CONCENTRATIONS - SUMMER SEASON

DATE	25 BLINN STREET				60 CARROLL ROAD			
	FAR OUTSIDE	NEAR OUTSIDE	NEAR INSIDE	FAR INSIDE	FAR OUTSIDE	NEAR OUTSIDE	NEAR INSIDE	FAR INSIDE
9/10	0.92	0.94	0.85	0.84	*****	*****	*****	*****
9/11	0.62	0.62	0.68	0.66	*****	*****	*****	*****
9/12	0.78	0.75	0.77	0.80	*****	*****	*****	*****
9/13	0.52	0.52	0.57	0.57	*****	*****	*****	*****
9/14	1.20	1.21	1.15	1.15	*****	*****	*****	*****
9/15	1.06	1.00	0.97	0.97	1.39	1.36	1.37	1.33
9/16	1.00	1.02	1.00	1.01	1.05	1.03	1.04	1.09
9/17	1.07	1.16	1.14	1.16	1.09	0.97	0.86	1.06
9/18	1.18	1.20	1.14	1.12	1.14	1.12	1.05	1.07
9/19	0.75	0.69	0.71	0.74	0.69	0.68	0.77	0.74
9/20	0.64	0.61	0.66	0.66	0.42	0.43	0.55	0.55
9/21	0.74	0.77	0.74	0.74	0.62	0.68	0.68	0.72
9/22	0.71	0.73	0.65	0.64	0.60	0.65	0.57	0.61
9/23	0.57	0.57	0.56	0.56	*****	*****	*****	*****
9/24	0.69	0.65	0.64	0.64	*****	*****	*****	*****
9/25	1.99	1.43	1.25	1.21	*****	*****	*****	*****
9/26	0.67	0.70	*****	*****	*****	*****	*****	*****
9/27	0.81	0.82	0.82	0.82	*****	*****	*****	*****
9/28	*****	*****	*****	*****	0.80	0.76	0.76	0.72
9/29	*****	*****	*****	*****	*****	*****	*****	*****
RATIO OF AVERAGES	0.80	0.79	0.76	0.76	0.76	0.76	0.77	0.78

TABLE 5-46

DAY/NIGHT RATIO FOR CO CONCENTRATIONS - FALL SEASON

DATE	CITY HALL FAR OUTSIDE	 NEAR OUTSIDE	 NEAR INSIDE	 FAR INSIDE	PUBLIC LIBRARY FAR OUTSIDE	 NEAR OUTSIDE	 NEAR INSIDE	 FAR INSIDE
10/ 9	1.01	0.87	0.85	0.84	1.06	1.00	0.95	0.98
10/10	0.75	0.62	0.61	0.63	0.88	0.77	0.73	0.72
10/11	0.80	0.81	0.62	0.61	0.97	0.88	0.83	0.87
10/12	0.57	0.62	0.66	0.66	0.80	0.65	0.63	0.61
10/13	3.53	2.84	2.24	2.23	0.01	0.01	0.00	0.00
10/14	1.91	1.76	1.69	1.76	0.01	0.00	0.00	0.01
10/15	0.68	0.77	0.73	0.74	0.83	0.78	0.69	0.72
10/16	2.04	1.96	2.10	2.12	2.06	1.73	1.67	1.64
10/17	1.01	1.07	0.95	0.97	1.27	1.18	1.11	1.11
10/18	0.78	0.79	0.65	0.66	0.96	0.86	0.76	0.77
10/19	1.98	2.04	1.67	1.65	1.96	1.69	1.50	1.47
10/20	2.43	1.86	1.77	1.66	2.23	1.88	1.65	1.64
10/21	2.20	2.48	1.69	1.68	1.96	2.18	1.58	1.62
10/22	2.78	2.67	2.35	2.28	2.65	2.09	1.82	1.84
RATIO OF AVERAGES	1.30	1.24	1.14	1.14	1.30	1.15	1.04	1.05

TABLE 5-47

DAY/NIGHT RATIO FOR CO CONCENTRATIONS - FALL SEASON

DATE	100 CONS.PLAZA FAR OUTSIDE	NEAR OUTSIDE	NEAR INSIDE	FAR INSIDE	250 CONS.PLAZA FAR OUTSIDE	NEAR OUTSIDE	NEAR INSIDE	FAR INSIDE
10/31	0.00	0.00	0.00	0.00	0.90	0.91	1.08	1.08
11/ 1	0.93	0.93	0.94	0.93	0.87	0.87	0.85	0.84
11/ 2	2.25	2.52	3.13	3.22	1.89	1.92	1.73	1.73
11/ 3	1.23	1.30	1.26	1.20	1.16	1.11	1.36	1.37
11/ 4	1.40	1.52	1.41	1.45	*****	*****	*****	*****
11/ 5	2.41	2.34	2.38	2.42	0.00	0.00	0.00	0.00
11/ 6	1.74	2.18	1.89	1.97	2.16	2.30	1.97	2.60
11/ 7	1.10	0.94	0.94	0.96	1.22	0.96	0.89	0.89
11/ 8	0.71	0.68	0.65	0.65	0.68	0.69	0.56	0.57
11/ 9	0.00	0.00	0.00	0.00	2.20	2.23	2.22	2.12
11/10	1.87	2.42	2.26	2.27	2.84	2.73	2.29	2.28
11/11	2.65	2.47	2.57	2.58	1.56	1.31	1.96	1.86
11/12	1.20	1.21	1.07	1.08	2.11	1.88	1.06	1.04
11/13	0.84	1.11	1.05	1.06	1.13	1.05	0.94	0.95
RATIO OF AVERAGES	1.37	1.43	1.42	1.44	1.37	1.31	1.24	1.25

TABLE 5-48

DAY/NIGHT RATIO FOR CO CONCENTRATIONS - FALL SEASON

DATE	25 BLINN STREET FAR OUTSIDE	NEAR OUTSIDE	NEAR INSIDE	FAR INSIDE	60 CARROLL ROAD FAR OUTSIDE	NEAR OUTSIDE	NEAR INSIDE	FAR INSIDE
11/19	1.00	1.00	1.00	1.00	1.61	1.54	1.33	1.30
11/20	0.00	0.00	0.00	0.00	1.43	1.48	1.60	1.53
11/21	0.00	0.00	0.00	0.00	1.70	1.72	1.56	1.46
11/22	1.19	1.19	1.19	1.19	1.22	1.18	1.17	1.18
11/23	0.67	0.66	0.64	0.64	0.70	0.68	0.68	0.69
11/24	1.50	1.46	1.64	1.64	1.92	1.69	1.91	1.92
11/25	1.63	1.53	1.50	1.48	1.18	1.16	1.15	1.16
11/26	0.54	0.58	0.57	0.55	0.56	0.53	0.71	0.74
11/27	1.19	1.21	1.11	1.13	1.18	1.18	1.28	1.28
11/28	0.61	0.59	0.59	0.58	0.58	0.58	0.64	0.64
11/29	0.23	0.25	0.33	0.33	0.47	0.49	0.44	0.45
11/30	4.84	4.69	3.26	3.07	2.07	1.94	1.79	1.82
12/ 1	1.66	1.63	1.54	1.56	1.97	1.85	2.88	1.89
12/ 2	1.45	1.51	1.34	1.24	3.97	2.86	1.47	1.44
RATIO OF AVERAGES	0.95	0.95	0.92	0.91	1.23	1.14	1.13	1.08

TABLE 5-49

DAY/NIGHT RATIO FOR CO CONCENTRATIONS - WINTER SEASON

DATE	CITY HALL				PUBLIC LIBRARY			
	FAR OUTSIDE	NEAR OUTSIDE	NEAR INSIDE	FAR INSIDE	FAR OUTSIDE	NEAR OUTSIDE	NEAR INSIDE	FAR INSIDE
1/12	2.32	2.82	2.18	2.13	2.80	2.44	2.35	2.33
1/13	2.85	2.12	2.28	2.34	2.57	2.33	1.68	1.73
1/14	2.61	2.50	2.38	2.32	3.23	3.09	2.76	2.71
1/15	2.58	2.02	2.16	2.16	2.50	2.17	2.18	2.18
1/16	1.84	1.62	1.37	1.35	1.51	1.41	1.22	1.21
1/17	0.30	0.32	0.34	0.35	0.39	0.37	0.32	0.32
1/18	2.92	2.78	2.73	2.77	3.29	2.88	3.44	3.53
1/19	3.26	2.60	2.89	2.85	3.30	2.70	2.82	2.75
1/20	3.08	2.49	2.10	2.09	1.90	2.24	1.49	1.46
1/21	4.08	4.48	3.42	3.33	4.32	3.98	3.16	3.08
1/22	1.74	1.76	1.52	1.50	2.02	1.70	1.66	1.67
1/23	1.11	1.07	1.05	1.03	*****	*****	*****	*****
1/24	1.22	1.17	1.17	1.16	0.00	0.00	0.00	0.00
1/25	2.85	2.33	2.52	2.57	2.87	2.63	2.38	2.36
RATIO OF AVERAGES	2.02	1.88	1.76	1.74	2.09	1.92	1.73	1.73

TABLE 5-50

DAY/NIGHT RATIO FOR CO CONCENTRATIONS - WINTER SEASON

	100 CONS.PLAZA				250 CONS.PLAZA			
DATE	FAR OUTSIDE	NEAR OUTSIDE	NEAR INSIDE	FAR INSIDE	FAR OUTSIDE	NEAR OUTSIDE	NEAR INSIDE	FAR INSIDE
1/30	1.88	1.85	1.60	1.61	3.21	2.16	1.78	1.81
1/31	0.96	0.99	0.88	0.88	1.32	1.25	1.17	1.14
2/ 1	1.13	1.03	1.27	1.29	2.52	1.74	1.05	0.99
2/ 2	4.15	4.12	3.15	3.07	6.90	7.31	5.14	4.65
2/ 3	1.65	1.92	1.76	1.76	3.32	3.09	3.45	3.36
2/ 4	1.79	1.96	1.90	1.88	1.88	1.75	2.47	2.45
2/ 5	1.81	1.66	1.47	1.44	1.88	1.90	1.73	1.85
2/ 6	0.61	0.65	0.57	0.57	0.61	0.71	0.60	0.61
2/ 7	0.54	0.53	0.53	0.53	0.61	0.57	0.57	0.57
2/ 8	1.48	1.51	1.51	1.52	1.60	1.33	1.31	1.28
2/ 9	1.30	1.40	1.00	0.96	1.65	1.56	1.49	1.49
2/10	2.13	2.38	1.81	1.80	4.58	5.08	2.79	2.67
2/11	1.55	1.59	1.37	1.38	3.02	2.61	2.04	2.01
2/12	1.39	1.50	1.25	1.27	1.63	1.60	1.39	1.41
RATIO OF AVERAGES	1.26	1.30	1.18	1.18	1.75	1.59	1.38	1.38

TABLE 5-51

DAY/NIGHT RATIO FOR CO CONCENTRATIONS - WINTER SEASON

DATE	25 BLINN ST. FAR OUTSIDE	NEAR OUTSIDE	NEAR INSIDE	FAR INSIDE	60 CARROLL RD. FAR OUTSIDE	NEAR OUTSIDE	NEAR INSIDE	FAR INSIDE
2/26	0.83	0.76	0.83	0.82	0.87	0.87	0.93	0.92
2/27	1.04	1.14	1.12	1.12	0.92	0.90	0.90	0.94
2/28	0.00	0.00	0.00	0.00	1.23	1.26	1.12	1.13
3/ 1	1.29	1.35	1.32	1.23	1.31	1.28	1.23	1.24
3/ 2	1.75	1.72	1.66	1.56	1.28	1.21	1.23	1.23
3/ 3	0.30	0.35	0.32	0.33	0.41	0.39	0.45	0.46
3/ 4	2.64	2.86	2.45	2.33	1.37	1.31	1.14	1.13
3/ 5	1.37	1.54	1.26	1.22	1.06	1.07	0.93	0.96
3/ 6	0.84	0.85	0.89	0.90	0.00	0.00	0.00	0.00
3/ 7	0.44	0.59	0.48	0.48	0.41	0.42	0.49	0.50
3/ 8	0.00	0.00	0.00	0.00	1.22	1	1.24	1.25
3/ 9	1.48	1.39	1.38	1.35	1.26	1.	1.14	1.13
3/10	1.43	1.28	1.25	1.26	1.25	1.26	1.18	1.22
3/11	2.16	2.31	2.03	1.97	1.30	1.18	1.41	1.36
RATIO OF AVERAGES	0.98	0.97	0.98	0.97	0.92	0.87	0.91	0.92

calibration and should represent the potential minimum ventilation of each at the time. The tracer gas was distributed manually through each structure in sufficient quantity to raise inside concentrations to the order of 50 to 100 ppm. By the time this concentration decayed to an on-scale value of about 25 ppm, the gas was reasonably well mixed through the interior. Subsequent decay was approximately exponential, from which the exponential decay constant was deduced from several measurements of the record. An interesting point was the indication of a gradient in each house from the far inside to the near inside positions of about 10 percent. In the summer calibrations at 25 Blinn Street, the front and back doors were opened after the test commenced and had to be repeated. From this we learned that opening these doors under the circumstances (light winds, late summer) lowered the decay constant from 90 to 10 minutes. The results of the diffusion experiments were:

EXPONENTIAL TIME CONSTANT OF BUILDING DIFFUSITY

	Summer	Fall	Winter
25 Blinn Street	90 min.	50 min.	55 min.
60 Carroll Road	90 min.	70 min.	70 min.

6.0 DISCUSSION OF RESULTS

The discussions in this section are based primarily upon the data analyses and the background information concerning the experiments. We will draw upon and refer to analytical observations contained in the interim report on the summer program but will not reproduce here the figures showing pollution episodes which were included in the summer report to show calibrations and certain penetration mechanisms.

One caution we must offer for the inspection of this data. The sampling periods of two weeks, one week, or three days, as the case may be, are not long for statistical purposes and the mean data will still contain significant sampling errors. Thus, in the data we will be looking for broad features and trends and less for individual and unsupported anomalies.

6.1 Suspended Particulate

The penetration of suspended particulates into structures is a complex measurement problem, compounded by the indoor generation or regeneration of particulates. Open, naturally ventilated structures such as typical residences and older office buildings during summer months, must take in dust approaching external concentration levels and we have some evidence here that internal levels may exceed those outdoors. We also see that public buildings, subjected to extensive evening cleaning and a restricted period of daytime activity and exposure to outside elements, can have internal levels well below those outdoors, despite many open windows. Air conditioning systems further complicate the considerations here, but in sealed buildings they can substantially reduce the penetration of particulate, depending on their character and management. Their beneficial effects are partially nullified, however, by internal generation which must be a function of building cleanliness, activity and entrance factors. It is against this background that we inspect the suspended particulate data.

The summer season measurements offer a daily detail of suspended particulate masses not available in the fall and winter programs. This detail is presented in Figures 5-1 to 5-6. An examination of the day-to-day data shows a number of instances where the respirable fraction of particulate is greater than the total particulate. This is illogical and is not likely attributable to errors in sample flows. In consequence, we examined twenty-two pairs of respirable/total particulate filters which had greater respirable fractions than total particulate matter. Under a 25-power microscope, all the respirable filters had visible quantities of clear fibrous particles while the total filters had no such particles. On comparing our visual findings with representative particle photographs from a particle atlas, it appeared that the unknown particles were pieces of the foam used as a pre-filter. We then examined a few respirable total particulate filter pairs, where the total was greater than the respirable fraction, a normal expectation. In this limited sample, all the respirable filters had some foam particles on them. With these results in mind, it appears difficult to rely on the respirable fraction results, as a great many filters were contaminated to an unknown extent with foam particles. However, the respirable measurements are valuable in placing an upper limit to the respirable fraction as defined by the method (ref. p. 8) and subsequent extraction of organic materials with benzene is probably valid.

An inspection of the measurements of suspended particulate for the three seasons in Tables 5-1, 5-6 and 5-8, show a range of concentrations from as low as 20 $\mu g/m^3$ inside the office buildings at night, to a high of 460 $\mu g/m^3$ as a week-long mean of daytime concentrations outside the Library in wintertime. One must note that Table 5-1 contains two-week means of total collections only. The summer measurements show reasonably clean air inside buildings and outside the residences. The outside air is increasingly dirtier as one proceeds to the office buildings and further to the public buildings. The fall measurements do not differ significantly from those of the summer. The primary change in the winter is the increase in outside concentrations, to a moderate degree at the residences and office buildings, and to a marked degree at the public buildings. It is interesting to compare the inside concentrations for the three seasons. The public buildings maintain about the same concentration of inside suspension through the three seasons, without regard to the marked increase in outside concentration in the winter. Obviously, the closed windows in the winter counteract the increased outside concentrations, but one could also postulate that inside concentrations were only a function of inside activities. The Plaza becomes cleaner in the fall and there is a corresponding drop in inside suspension, but there is not a corresponding rise in inside particulates with moderately increased winter concentrations outside. This is most likely a function of a drop in make-up ventilation air in the winter. At the residences we see much the same particles inside as outside, both from mass and particle size aspects, in the summer at both homes, and in the fall at Carroll Road during the day. One can see the effect of weather-induced reduction in controllable ventilation during the fall at Blinn Street, and at both homes during the winter. Inside suspensions at the homes during the winter are quite comparable with the modern office buildings.

Some of the above comments are quantized in the ratio tables for suspended particulates. Far inside/far outside ratios are near 0.5 for the summer and fall seasons at the public buildings and office buildings, dropping in the winter to as low as 0.16 at the Library, 0.3 at the City Hall, and ranging from 0.3 to 0.5 at the office buildings. As we have seen, this ratio is near 1.0 at the residences in the summer, decreasing to about 0.5 as winter approaches.

A two-stage particle size distribution is inherent in the Roesler prefilter technique (ref: p. 8) used in the summer program. The particle size cutoff is near 2.5 inches. The problems with the method have been described and the "respirable" results in Table 5-1 must be used with caution. However, some comparisons can be made for the summer season measurements. The portion of dust below 2.5 microns diameter would seem to range from about half in the daytime outside the public buildings to about two-thirds or three-quarters at night and outside the other buildings at all times. Inside the buildings the finer dust predominates, the portion ranging from three-quarters up to one. This suggests that the mass median diameters of the particulates range from about 2.5 microns outdoors of the public buildings downwind to rather low values inside the office buildings and residences. The better defined techniques used for the fall and winter seasons tend to confirm the approximate summer findings. Values listed in Tables 5-10 and 5-11 are the individual fractions and must be accumulated to estimate the mass median diameters for each sample. In both, the outside particulates at the public buildings have mmd's of approximately 2.5 microns, with the exception of the fall measurements at City Hall. We feel that the latter measurements are unreliable upon reconsideration of the raw data. The original fall measurements at the Library were discarded at the time because of power interruptions and were repeated later in the season. The measurements at the City Hall were then the first in the series and appear to have suffered in quality. Proceeding to the other buildings we find that the mmd. of the outside particulates was in the range of 0.4 to 0.8 microns. Inside the structures, the dust was finer, with mmd's well below 0.4 microns. Of the groups, the coursest dust was present in the residences where it most nearly corresponded to the particle size distributions outdoors.

Both the organic (benzene soluble) mass fraction and inorganic lead fraction of the suspended particulate were extracted from selected filter collections and assayed. The most notable observations of the benzene soluble fraction, Table 5-12, were the wide variations in both suspended concentration and portion of total collection. We tentatively conclude that the organic material is contained primarily in the particles of less than 2.5 micron diameter and in the particles which have ready ingress to the structures. combined with out previous assessment of the particles sizes inside, it would appear that the organic material is largely contained in particles of the order of 0.5 micron diameter or less. The large unpatterned variations of organic content expressed as a portion of the total collections (percent) would confirm a lack of a common structure for suspended particulates.

The inorganic lead fraction, Table 5-13, is listed for the same locations and periods as the previous data. Values range downward from 4 $\mu gm/m^3$. In these measurements, there is less suggestion that the lead is contained in any particular particle size regime, or that there is a strong selection factor operating in its penetration into structures. Instead, the proportion as a percent of total collected mass appears to be relatively conservative during penetration, particularly in the fall measurements. In the winter there are greater variations in both indices, proportions generally increasing as concentrations decrease with penetration. Thus, the greater portion of the lead may be concentrated in the more readily penetrating finer particles during the winter.

Taking the liberty of declaring four measurements suspect, the remainder of the lead data falls into a rational pattern. There are high concentrations of lead in all seasons at Blinn Street, obviously reflecting the heavy traffic on Interstate 84, Pitkin Street and Main Street, which together surround the residence within the distance of one block. Carroll Road, while adjacent to Interstate 84 is not as exposed to heavy traffic to the north and is further from Main Street to the east. The Library site shows heavy concentrations of lead, particularly in fall and winter, with lesser concentrations at the City Hall location. While both outdoor sites are similarly located, that at the Library was sandwiched between a small but active parking area and the submerged feeder to Interstate 91. The similarly located parking area at the City Hall is smaller and less active but the site is near the corner of two busy city streets. The office buildings are subject to less lead in their surrounding environment, at least in the vicinity of the outside collectors which do not necessarily represent street-level concentrations. Low concentrations in the summer, increasing markedly in the fall and still further in the winter, probably represent a general downtown background level contributed by an extensive area of local traffic and the two interstate highways, 84 and 91. The lesser nighttime concentrations at the various sites, despite poorer atmospheric diffusivity, rationally reflect the changing traffic densities. The streets are quite bare at night except for shopping evenings, leaving only a moderate traffic on the interstate highways as the major source of lead contamination.

6.2 Soiling Particulates

The measured soiling indices, all expressed as COH/1000', are remarkable only in their rather low values. Rarely does the season average at a sampling point exceed 0.5, with averages ranging from 0.2 inside the Plaza buildings in the fall to 0.7 outside 250 CP in the winter. Individual 2-hour data occasionally exceed 1.0 and 12-

hour means do so twice. There is considerable uncertainty concerning just what the index measures. A day-to-day comparison between the 12-hour mean index and the daily 12-hour suspended particulate collections in the summer show only a vague correlation. However, an inspection of the 2-hour data in the Data Summaries show a rational behavior in the index, relating it to known changes in the environment and in activity levels.

Soiling material readily penetrates open buildings such as the City Hall in summer but suffers considerable attenuation in penetrating the office buildings, particularly 250 CP. Nowhere, though, is it attenuated to the extent that suspended particulates are in general. There is evidence in the data that some soiling material is internally generated. Inside indices at Carroll Road are higher than outside in the summer, a situation partly paralleling the suspended particulate anomaly at the same time. We also show index ratios above 1.0 at the City Hall in the fall. However, these ratios differ from 1.0 by less than possible errors in the measurement. Significantly large attenuation on penetration occurs primarily at 250 CP in the summer and winter seasons and at the public Library in the winter. The former may be tied to the reduction in makeup ventilation air during the heat of summer and cold of winter and the latter to the closed ventilation state of the Library in the winter and its usually low occupancy level, although the same comments could apply to 100 CP and the City Hall where similarly marked decreases do not occur. The ratio of day to night soiling levels is remarkably consistent through related sampling points. Daytime soiling is usually higher than nighttime soiling at the public buildings, lower at the residences and about the same at the office buildings. This trend is consistent with the trends of similar ratios for suspended particulates.

6.3 Carbon Monoxide

The behavior of carbon monoxide in entering and leaving structures appears to be very conservative and predictable from the results in this program. Outside concentrations for 2-hour periods range up to about 25 ppm but season means do not exceed 7.5 ppm. Concentrations are least in the summer, least at the Plaza buildings, and less at night in Hartford but greater in East Hartford. An inspection of the data in the three supplements show strong concentrations at the time of morning and late afternoon traffic peaks, particularly at the public buildings.

The statistical information in Tables 5-35 to 5-37 show remarkable uniformity where it should be expected in each situation. The minor increased concentrations at the far outside positions at the public buildings are consistent with the closer proximity of traffic and this increase is less at night, as might be expected. A minor variation exists at the building wall in the office buildings, reflecting the type of construction. Concentrations inside 100 CP are consistently higher than outside and is believed due to the management of the air conditioning system. At 250 CP any similar effect appears to be masked by a greater sensitivity to street sources of carbon monoxide during the day. At the residences the carbon monoxide seems to have full access, inside/outside ratios all being slightly in excess of 1.0. The ratio increases in winter at Carroll

Road, raising a question concerning internal generation not present in summer and fall. Because of the measurement methods, these differences of a few percent are probably real.

Ventilation arrangements in the office buildings at Constitution Plaza lead to an interesting phenomena, particularly evident at 100 CP. The ventilation system is not operated nighttime, or Sunday, and the original records show the sluggish response to outside changes during these off-hours. In the early morning, coincident with the commuter traffic peak, the building is initially ventilated and, depending upon outside temperatures, may later be ventilated at lower proportions of make-up air. In the interim summer report, facsimilies of recorder charts were presented showing the manner in which this procedure can elevate the levels of CO above those outside during the remainder of the morning. In the winter, the outside temperature precludes the use of high ventilation rates initially in the morning and we do see a lower ratio of inside to outside concentration. Undoubtedly, smoking by occupants and visitors advances the daytime ratio and may well be responsible for most of the daytime ratio of 1.13. In view of the action of the conditioning system, the nighttime ratios lose some of their significance but they suggest the carry-over of inside daytime pollution admitted from the late afternoon traffic peak.

The same phenomena may exist at 250 CP, but it is inherently a better ventilated building to suppress entrance of garage air, and the original charts show a much more rapid response to outside changes. More significantly, there is a gradient in the daytime from the far outside point to the near outside point which masks any tendency to an advanced inside/outside ratio. This gradient suggests that the nearby street some three floors below is a potent local source of CO. The absence of this gradient at night and in the summer would tend to confirm a local traffic source.

6.4 Sulfur Dioxide

The behavior of sulfur dioxide in and around the structures was not as neat and rational as for carbon monoxide, and we have, as background, serious concern for the validity of the measurements. This concern arises from two sources, the suitability and performance of the conductimetric analyzer and the potential loss by adsorption of SO_2 within the sampling system. The former factor has been discussed under instrumentation and field activities in this report. Pertinent to the latter is a recent paper* describing the ill effects of the polyethylene tubing, stainless steel filter holders and filter media used in the sampling train. Reducing the impact of some of the conclusions in the paper was the operation of the filters, holders, and stainless steel manifold at elevated temperatures of either 80°F or 10°F above outside ambient, whichever was higher, and the use of no filter medium or holder in the common path to the analyzer. An inspection of the season averaged concentrations in fall and winter in which both inside/outside ratios and day/night ratios are all near one. This is an unlikely occurrance, in view of different indoor/outdoor humidity conditions, if the sampling systems were strongly adsorbing SO_2. In addition, the frequently noted sharpness of the change in measured concentration at each 5-minute sample period would suggest no significant adsorption and desorption of SO_2 after the control solenoid positions. Considering all the evidence, we have tentatively accepted the results published here but cannot assign the same degree of accuracy and confidence to them which we have for the carbon monoxide measurements.

---

*Byers, R. Lee and John W. Davis, Sulfur Dioxide Adsorption and Desorption on Various Filter Media, J. APCA, 20(4), 236-238 (April, 1970).

In reporting the summer program we omitted the sulfur dioxide data at the public and office buildings. An inspection of the original records showed that any SO_2 outside was at levels of concentration below the capability of the instrumentation to measure at the time. However, the measurements in late summer at the residences were more promising and these were processed. The summery (Table 5-39) shows, however, that outside concentrations were low and probably below the effective noise level of the instrumentation. In addition, the increased concentrations inside at Carroll Road and also inside during the day at Blinn Street are not believed to be real. Measurements were hampered by advanced levels of carbon dioxide inside these homes, particularly Carroll Road where inside CO_2 was frequently double the outside CO_2. Large ratios of CO_2 compounded by inadequate flow control in the analyzers can imply an erroneous inside concentration of SO_2. For these reasons we feel that these summer data are dubious. Before the fall program we rebuilt the scrubber cycle, and have more confidence in later results.

In the fall measurements the levels of SO_2 were still rather low and the results questionable. The data taken at the Library and at 100 CP are too near the instrumentation noise level to be reliable,

SUMMARY OF FAR INSIDE/FAR OUTSIDE RATIOS OF POLLUTANTS

	SUMMER			FALL			WINTER	
LIBRARY:	Day	Night		Day	Night		Day	Night
Suspended Particulate	0.50	0.52		0.38	0.44		0.16	0.24
-- For Selected Week	0.54	0.55	[0.96]	0.45	0.48	[0.34]	0.15	0.22
-- Organic Fraction	0.67	1.70		0.73	0.89		0.47	0.48
-- Lead Fraction	0.49	0.54		0.54	0.49		0.42	0.26
Soiling Index	0.81	0.81		0.92	0.94		0.50	0.49
Carbon Monoxide	0.87	1.00		0.78	0.96		0.84	1.01
Sulfur Dioxide	-	-		3.00	2.08		0.95	0.96
CITY HALL:								
Suspended Particulate	0.51	0.63		0.62	0.53		0.27	0.30
-- For Selected Week	0.47	0.58		0.63	0.57	[0.50]	0.29	0.29
-- Organic Fraction	0.78	1.17		1.02	0.52		0.97	0.50
-- Lead Fraction	1.06	0.92		-	0.55		0.67	0.61
Soiling Index	0.98	1.00		1.15	1.14		0.94	0.93
Carbon Monoxide	0.89	1.02		0.89	1.01		0.80	0.93
Sulfur Dioxide	-	-		1.18	1.14		0.85	0.79
100 CONSTITUTION PLAZA:								
Suspended Particulate	0.48	0.49		0.75	0.71		0.31	0.48
-- For Selected Week	0.44	0.48	[1.17]	0.88	0.82	[0.49]	0.26	0.44
-- Organic Fraction	1.08	1.47		2.66	0.91		0.78	0.73
-- Lead Fraction	0.39	0.75		0.39	-		0.35	0.64
Soiling Index	0.87	0.83		0.69	0.79		0.85	0.89
Carbon Monoxide	1.31	1.00		1.32	1.25		1.13	1.21
Sulfur Dioxide	-	-		0.82	0.56		0.75	0.77
250 CONSTITUTION PLAZA:								
Suspended Particulate	0.45	0.55		0.58	0.50		0.33	0.33
-- For Selected Week	0.34	0.52		0.64	0.56	[0.40]	0.27	0.35
-- Organic Fraction	1.02	0.97		1.55	0.67		0.66	0.51
-- Lead Fraction	0.92	-		0.35	0.41		0.32	0.69
Soiling Index	0.57	0.62		0.79	0.84		0.58	0.55
Carbon Monoxide	1.05	1.02		0.97	1.04		0.76	0.96
Sulfur Dioxide	-	-		-	-		0.84	1.00
25 BLINN STREET:								
Suspended Particulate	0.89	0.86		0.56	0.61		0.43	0.41
-- For Selected Week	0.97	0.90	[0.60]	0.58	0.63	[0.49]	0.51	0.47
-- Organic Fraction	-	1.50		0.83	0.96		1.07	0.43
-- Lead Fraction	0.85	0.65		0.39	0.48		0.52	0.71
Soiling Index	0.89	0.85		0.88	0.89		0.82	0.74
Carbon Monoxide	1.02	1.07		1.03	1.08		1.07	1.08
Sulfur Dioxide	2.50	1.67		0.54	0.62		0.77	0.81
60 CARROLL ROAD:								
Suspended Particulate	1.15	0.84		0.97	0.62		0.51	0.39
-- For Selected Week	1.05	0.98	[1.44]	0.84	0.55	[0.29]	0.28	0.35
-- Organic Fraction	1.39	0.90		1.80	0.80		2.81	0.50
-- Lead Fraction	1.00	0.72		0.55	0.61		0.40	-
Soiling Index	1.19	1.10		0.80	0.67		0.93	0.83
Carbon Monoxide	1.04	1.02		0.96	1.08		1.12	1.12
Sulfur Dioxide	-	9.30		0.91	0.25		0.45	0.06

NOTE: Bracketed quantity is potential Indoor/Outdoor ratio for particulates of less than 0.44 micron diameter. See text for explanation.

and having been measured by the same analyzer, may have been degraded by poor instrumentation performance. The data for the other locations appear valid and so do the measurements made during the winter, when concentrations were generally higher. A broad view of these data suggests that some SO_2 is lost in penetrating the structures, with inside/outside ratios ranging from 0.5 to 1.0 but mostly between 0.75 and 1.0. The major exception is at Carroll Road where nighttime ratios dropped much lower. Considering the measurement uncertainty, we must interpret the Carroll Road results as implying that practically all SO_2 was lost in penetrating the structure at night. We have no explanation as to why this might be so. We also note, contrary to the general trend, that SO_2 concentrations in East Hartford were higher in late fall than in late winter.

6.5 Summary

The prime interest in this study is the relationship between inside and outside air pollution for a number of pollutants. To help the reader visualize the relationships measured, we have gathered all the inside/outside ratios into Table 6-1. Both day and night data for the three seasons are tabled for each structure. Suspended particulate, soiling index, carbon monoxide and sulfur dioxide data represent a two week mean (slightly more or less in the summer program), while the organic and lead fractions of the suspended particulate data are means during a selected one-week period. In addition, the suspended particulate ratio for the selected week is given, as background for the fractional data.

A potentially useful analysis factor can be derived from the particulate size measurements given in Tables 5-10 and 5-11. The inside/outside ratio for both the total suspended particulate, as measured by the apparatus, and the inside/outside ratio of any particulate size fraction can be computed. Then, assuming that all of one component or another was contained uniformly in that fraction, these two ratios should predict, by application to the known ratio for suspended particulate, the ratio for the component. In mathematical notation, as derived from the assumed identity:

$$\frac{(\mathrm{In/Out})_f}{(\mathrm{In/Out})_t}\,] = \frac{(\mathrm{In/Out})_f}{(\mathrm{In/Out})_t}\,]_A$$

Where: c = component
f = size fraction
t = total
A = fraction measurement (modified Andersen)

The relationship may be expressed as:

$$(\mathrm{In/Out})_{fc} = (\mathrm{In/Out})_{tc}\,\frac{(\mathrm{In/Out})_f}{(\mathrm{In/Out})_t}\,]$$ = predicted Inside/Outside ratio for particulate fraction

This prediction has been calculated for the size range of less than 0.44 microns effective diameter and placed within brackets in Table 6-1 in front of the pertinent suspended particulate ratio (selected week, daytime only). Thus, if a component material were distributed uniformly through a particulate, its inside/outside ratio should be that of the parent particulate, but if it were distributed uniformly only through the particles of diameter less than 0.44 microns, then its inside/outside ratio should be that of the predicted ratio in brackets. If the component is entirely in the superfine particles (as a limiting case) then its inside/outside ratio should approach the ratio for a conservative gas such as carbon monoxide. In applying this prediction we must recognize that the particle size sampling periods were not coincident with the periods during which the particulate samples for component analysis were collected. In the late fall and during the winter, the three-day size sampling period was either within the selected week or the adjacent week, but in the early fall the size samples were obtained significantly later than the particulate collections. These reservations must be kept in mind during analysis.

In viewing the apparent penetration of the organic and lead particulate fractions, we see an obvious difference. The organic fraction appears tc penetrate, in general, as easily as a conservative gas and certainly more readily than one would estimate from the prediction detailed in the previous paragraph. One would suspect a significant contribution by internal generation related to human activity as most of the major anomalies are daytime. The contribution is not solely related to household activities such as cooking as the effect is seen in all three pairs of buildings, although the homes do show the effect more consistently. We do not see the same consistent effect for the lead fraction. Lead fraction ratios are almost invariably less than those for carbon monoxide and generally lie near and above those for suspended particulates for the selected week. They occasionally rise above the index predicted above but more generally remain well below it. Thus, it would seem that the lead fraction does not benefit from any mechanism responsible for enhancing inside organic material. Indeed, if one is to accept the predicted index for the penetration of fine material, the lead does not penetrate as well as the fine particles collected on the final filters in the particle size collections. The most notable, or rational, behavior of both fractions is at Carroll Road in the summer, where one can assume rather open ventilation in daytime, and some restriction at night. There is an open penetration of CO gas and ratios of particulates are near one in daytime and slightly below one at night. The organic fraction shows a significantly higher ratio in daytime, perhaps an index of internal generation. A data array, such as this, is almost a calibration and conformation of the validity of the measurement techniques.

The behavior of the soiling index ratios is interesting. They rarely exceed those for CO and generally lie about midway between the ratios for CO and suspended particulate. The exceptions are the public buildings where the soiling index ratios are similar to the CO ratios despite falling particulate ratios. However, in the extreme case of the Library in winter, where particulate ratios drop to the order of 0.2, the soiling index ratio does drop to 0.5. We do not believe that there is sufficient activity in these buildings to generate significant soiling material. We can point out, however, that there is one other common factor involved in these two buildings, besides their exposure and natural ventilation. That is, the local area sampled in the City Hall is also a library for city records. Is higher soiling associated with the storage and use of books, particularly old books?

Finally, we can reiterate our statements about the behavior of the sulfur dioxide data. The limited summer results are not reliable, nor are the fall data at the public buildings. Starting with the office buildings in the fall, we see that ratios of sulfur dioxide rarely exveed corresponding ones for carbon monoxide and generally are less by about 25 percent. The gross exception is at Carroll

Road where winter ratios drop by a factor of two and nighttime ratios, fall and winter, drop by another factor of four or more. This would suggest either a strong attenuation during penetration or an internal sink. One might be tempted to postulate an internal sink/source to additionally explain the high ratios in the summer measurements, but a consideration of the reported summer concentrations against the background of high ventilation would be discouraging.

7.0 ACKNOWLEDGEMENTS

In a program of this nature, there are many who necessarily contribute to its successful conclusion. The authors have received invaluable assistance from NAPCA personnel, from householders and building superintendents, from our own personnel in field operations in analytical chemistry, and in data processing and clerical functions. The authors greatest debt lies, undoubtedly, with Mr. Gerald P. Guay of TRC, who personally managed and carried out most of the field measurement activities which form the basis of this report.

VOLUME II: SUMMARY REPORT - SUPPLEMENTAL STUDY

FINAL REPORT
CONTRACT NO. CPA 22-69-14

Prepared for the

NATIONAL AIR POLLUTION
CONTROL ADMINISTRATION

Prepared by:

John E. Yocom, Principal Investigator
William A. Cote, Assoc. Research Engineer
William L. Clink, Research Scientist

May. 1970

THE RESEARCH CORPORATION of New England
P. O. BOX 3335
HARTFORD, CONNECTICUT 06103

CONTENTS

Page

1.0 INTRODUCTION 125

2.0 SUMMARY AND CONCLUSIONS 126

3.0 SURVEY PLAN 128

  3.1 Sampling Sites 128

  3.2 Measurement Systems 129

4.0 RESULTS 133

  4.1 Gas-Fired Homes 133

    4.1.1 House G-1 133

    4.1.2 House G-2 136

  4.2 Coal-Fired Homes 138

    4.2.1 House C-1 138

    4.2.2 House C-2 141

APPENDIX: METEOROLOGICAL DATA 147

1.0 INTRODUCTION

This report covers a brief study of comparative indoor/outdoor concentrations of selected air pollutants at four single-family dwellings having either natural gas or coal-fired heating systems. This study is a supplement to the more ambitious studies conducted over two week periods, both summer and winter, for a wider range of building configurations.

This supplemental study had as its aim the development of limited data on the effect of home heating and cooking systems on indoor/outdoor pollutant relationships. During the late winter (1969) studies were carried out over 48-hour periods at two gas-heated homes where carbon monoxide (CO) only was measured, and at two coal-heated homes where CO, sulfur dioxide, and soiling particulate matter were measured.

While designated supplemental, the measurements for this study actually preceeded the main field program described in this series of reports.

2.0 SUMMARY AND CONCLUSIONS

Valid data covering 48-hour periods were collected on indoor-outdoor air pollutant relationships at four single-family dwellings - two each, gas and coal-heated. After some start-up difficulties the instrument packages operated satisfactorily. The following conclusions can be drawn from the results obtained:

1. The use of single instruments to sample a number of locations by means of solenoid valves and an appropriately designed sampling manifold is an excellent method for obtaining comparative indoor-outdoor air pollutant concentrations.
2. In the two gas-fired homes the heating system had no measureable effect on the indoor or outdoor CO levels; however, the gas fired stoves in each house had a significant influence on indoor CO levels.
3. Kitchen-generated contaminants diffuse readily through those parts of the house at the same elevation as the kitchen, but rooms at a lower level than the kitchen do not respond to the same extent as rooms on the same elevation.
4. Attached garages having a door opening from the garage directly to the house proper are a significant source of CO inside such houses.
5. CO and soiling particulate matter from external sources readily penetrated all homes. After some time lag, indoor concentrations assumed levels approximating those outdoors.
6. SO_2 from external sources penetrates homes but is lost to a variable extent depending upon what appear to be meteorological factors and levels of indoor activity.
7. In coal-fired hot air heating systems with apparent leaks, indoor concentrations of CO and SO_2 can approach levels capable of producing

adverse health effects.

8. Hot air heating systems cause rapid dispersal throughout the house of internally generated pollutants.

3.0 SURVEY PLAN

3.1 Sampling Sites

The basic criteria for the houses selected were that they be single family dwellings having either gas or coal heating systems in residential areas where pollutant levels would normally be low. In addition, the homeowners would have to be cooperative and there would have to be room for our sampling equipment. We were able to locate the two gas-burning homes among TRC employees by use of an interoffice memorandum. The two coal-burning homes were located through a local coal dealer who provided customer lists which were used to contact homeowners. Selecting two suitable locations was a lengthy process because most of the owners of coal fired homes were not interested in participating in the project.

The first gas-burning house (G-1) sampled was located in West Hartford, a residential suburb of Hartford, at a distance of 5 miles west of downtown Hartford and on a major east-west artery. The second gas-burning house (G-2) was located in Rocky Hill, a small town south of Hartford, 8 miles from downtown and near an interstate highway. The first coal-burning house (C-1) was located in South Windsor, a residential suburb, at a distance of 10 miles northeast of Hartford. The second coal-burning home (C-2) was located in the suburb of Windsor, 5 miles north of Hartford.

The two gas-burning homes (G-1 and G-2) were of frame construction and were 45 and 3 years old, respectively. Both homes were multi-level and had gas, hot water heating systems with gas stoves for cooking. Although both stoves had exhaust hoods over the cooking surfaces, neither was vented to the outdoors. The only smoker in both houses was the lady of the house at G-2. The two coal-burning homes (C-1 and C-2) were approximately 100 and 50 years old, respectively.

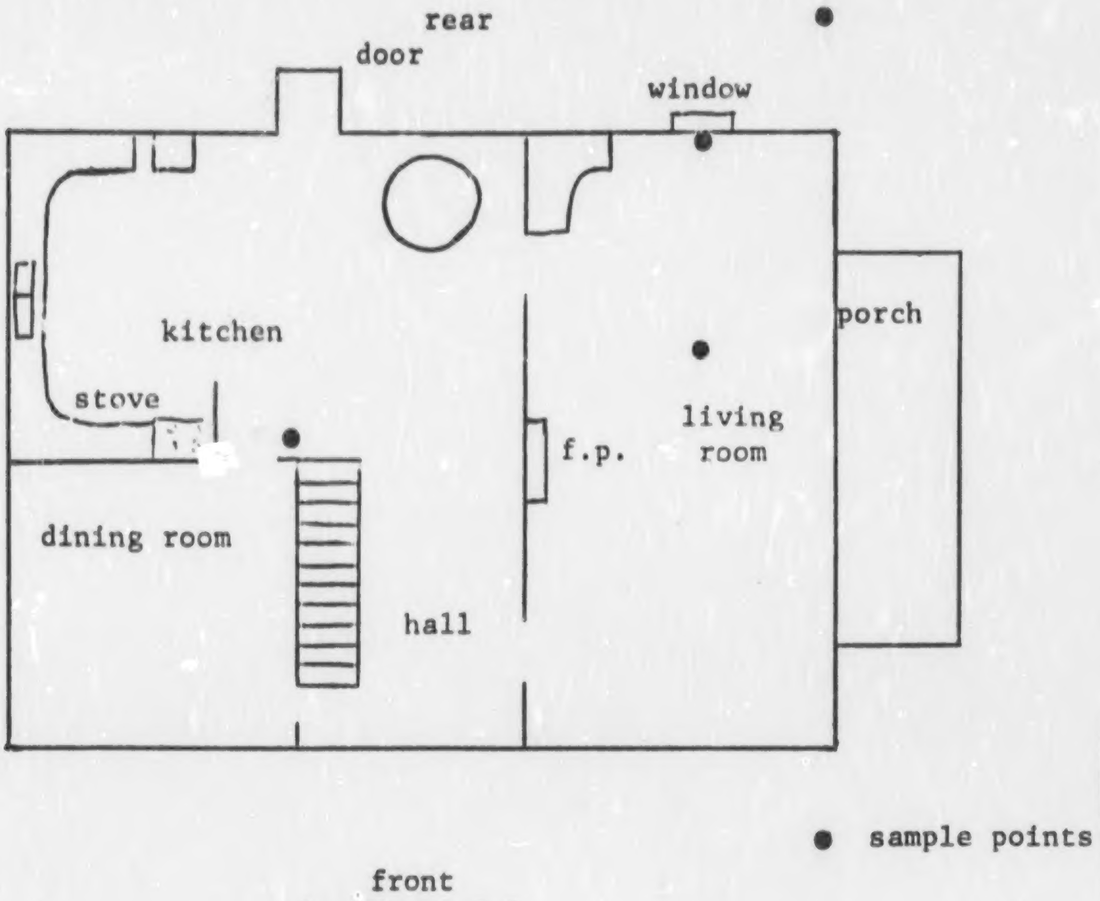
House C-1 was of brick construction and house C-2 was of frame construction. House C-1 had a gravity-feed, warm air furnace with a single central register in the living room, while house C-2 had a more modern steam-radiator system. A gas stove was used for cooking in house C-1 and an electric stove in house C-2. House C-1 was occupied by an elderly pipe-smoking gentleman and house C-2 by an elderly couple who were non-smokers. One other notable distinction between the two houses was appearance. House C-1 was considerably run down and unkempt as compared to house C-2.

Four different sampling locations were used at each of the houses studied. The sampling locations at the two gas-fired homes consisted of three indoor locations (one of which was located just inside a window) and one outdoors. For the coal fired homes, two of the sampling locations were immediately on the indoor and outdoor sides of a window. In all of the houses tested one of the sampling locations was in the kitchen. Figures 1 and 2 show the sampling location layout for the gas and coal-fired homes respectively.

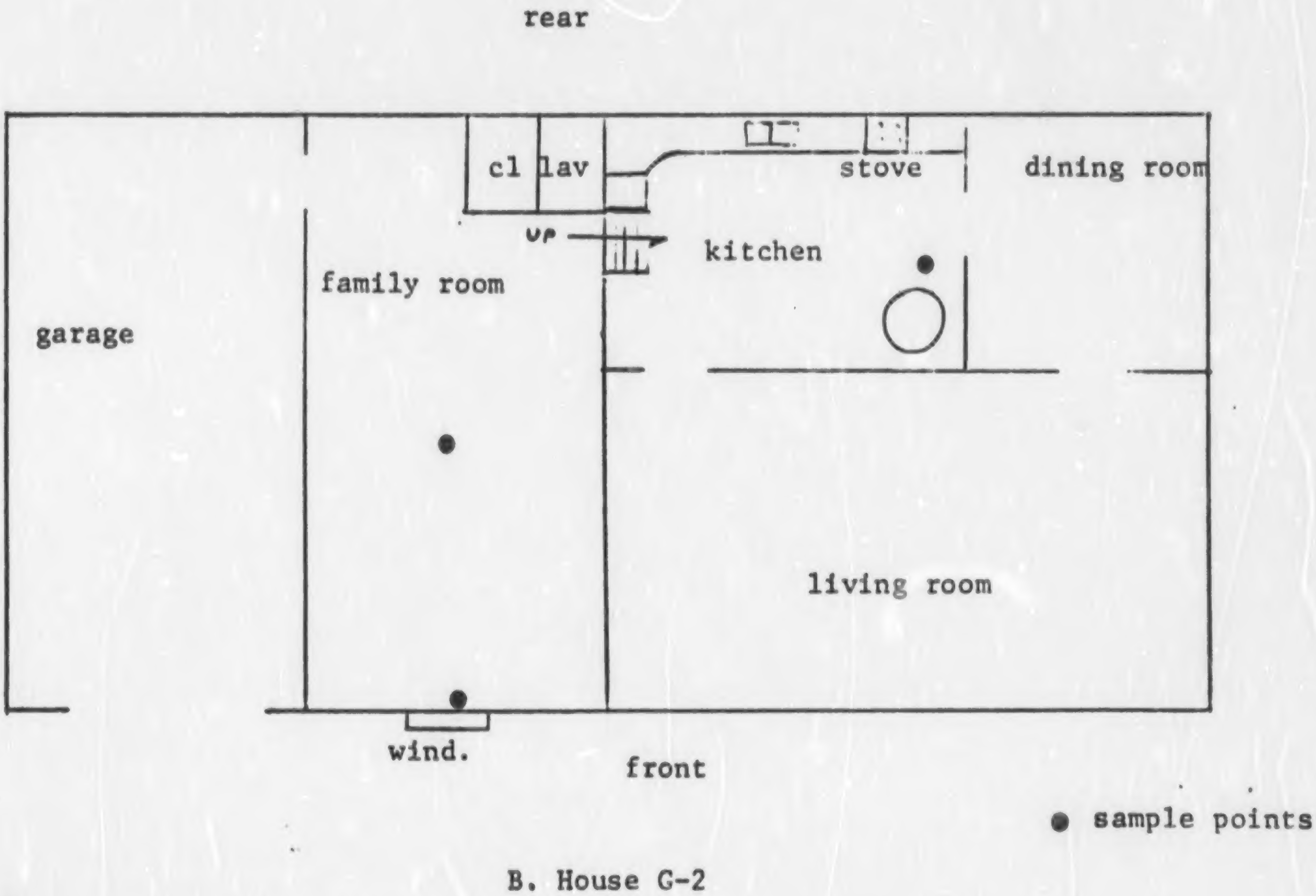
3.2 Measurement System

In the gas-fired homes only CO was measured. For these measurements an Intertech "Infra-2" non dispersive infrared continuous analyzer was used. It was controlled by the TRC designed electronic system described in Part I. The sampling locations were switched from one position to the next at 5-minute intervals. The basic system consisted of four sampling lines connected to four solenoid valves which were controlled by the master timer, a zero gas cylinder and valve, a bubbler for humidfying the sample gas, a pump, flowmeter, and dryer with both an outlet and recirculation lines, and the carbon monoxide analyzer itself with a particulate filter and flowmeter. Since this is a relatively small instrument package, we were able to locate it inside each of the two homes where we sampled.

FIGURE 1: Floor Plans of the Two Gas Burning Homes


rear
door
window
kitchen
stove
porch
living
room
f.p.
dining room
hall
front
● sample points

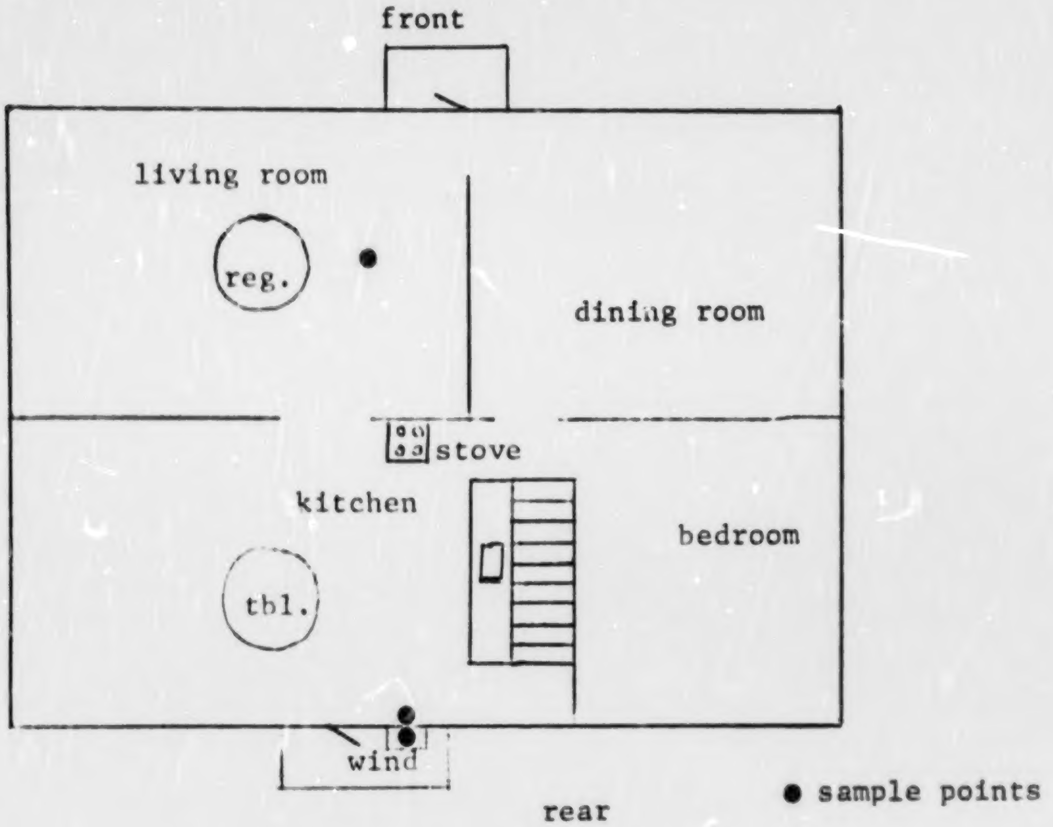
A. House G-1


rear
cl
lav
stove
dining room
UP
kitchen
family room
garage
living room
wind.
front
● sample points

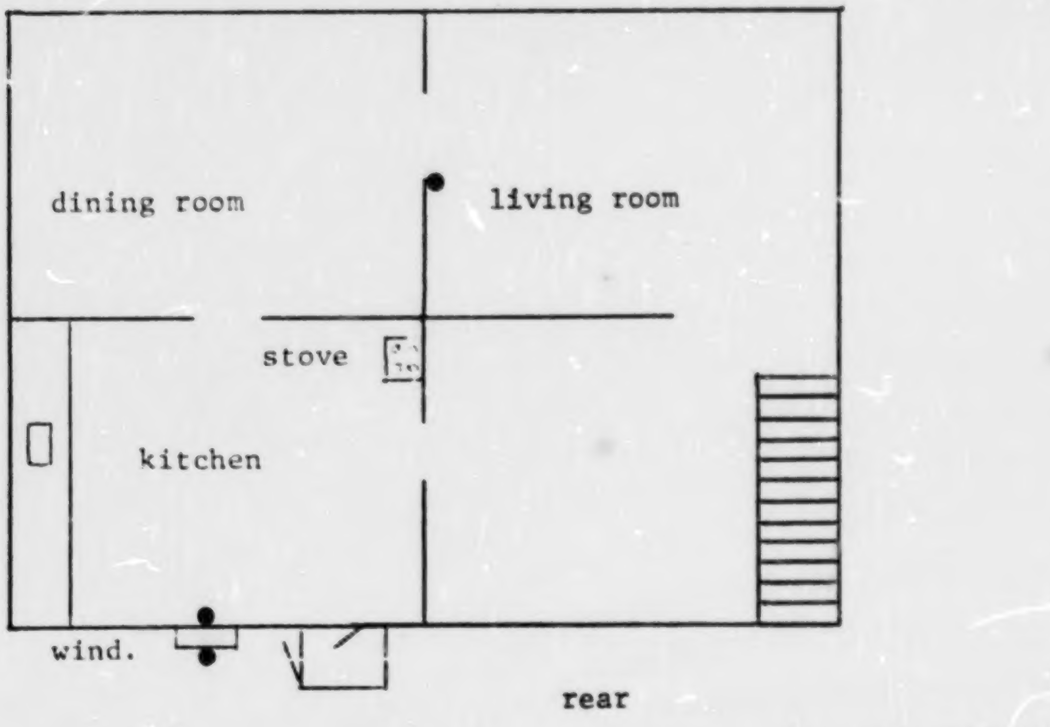
B. House G-2

Approximate Scale: 1" = 10'

Figure 2: Floor Plans of the Two Coal Burning Homes


front
living room
reg.
dining room
stove
kitchen
bedroom
tbl.
wind
rear
● sample points

A. House C-1


dining room
living room
stove
kitchen
wind.
rear
● sample points

B. House C-2

Approximate Scale: 1" = 10'

Polyethylene tubing was used to transport the sample gas from the points to the instrumentation. With a sampling time of five minutes at each of four locations a cycle required 20 minutes. Consequently, each point was sampled three times per hour. The total sampling period was 48 hours with the zero reading of the analyzer automatically checked every two hours.

The instrumentation package for sampling the coal-fired homes was more complex and was basically one of the instrument-equipped trailers used in the main sampling program with the exception of the suspended particulate portion of the sampling equipment. Essentially, the equipment used consisted of the carbon monoxide system described above, with the addition of a Sign-X Model 604-B SO_2 analyzer and Gelman paper-tape samplers for each of the four sample points. The trailer was located near the rear entrance at each house. Electricity was supplied by a direct hookup from the main power panel in the basement. As with the gas-burning homes, all sampling was controlled by the master timer and solenoid valve system. Sulfur dioxide and carbon monoxide samples were taken simultaneously for 5 minute periods at each of the four sample points. The paper tape samples were timed by the central control unit and sampled simultaneously at each of the four points on a two-hour basis. The total sampling time, as before, was 48 consecutive hours.

4.0 RESULTS

The emphasis in this supplemental study is on qualitative rather than quantitative indoor-outdoor differences, and the results are presented in terms of graphs showing the time history of pollutant concentrations at each of the four sampling points. Except for one graph which shows 5-minute averages, all of the graphs for gaseous pollutants are based on one-hour averages (average of three 5-minute "bits"). Concentrations are stated in terms of PPM (vol). Soiling particulate matter is based on 2-hour samples, and is stated in terms of COH/1,000 lineal feet. Although sampling at each house was carried out for as long as 5 days, only 48 hours of record was selected for presentation on the basis of its representativeness and general interest within the context of this study.

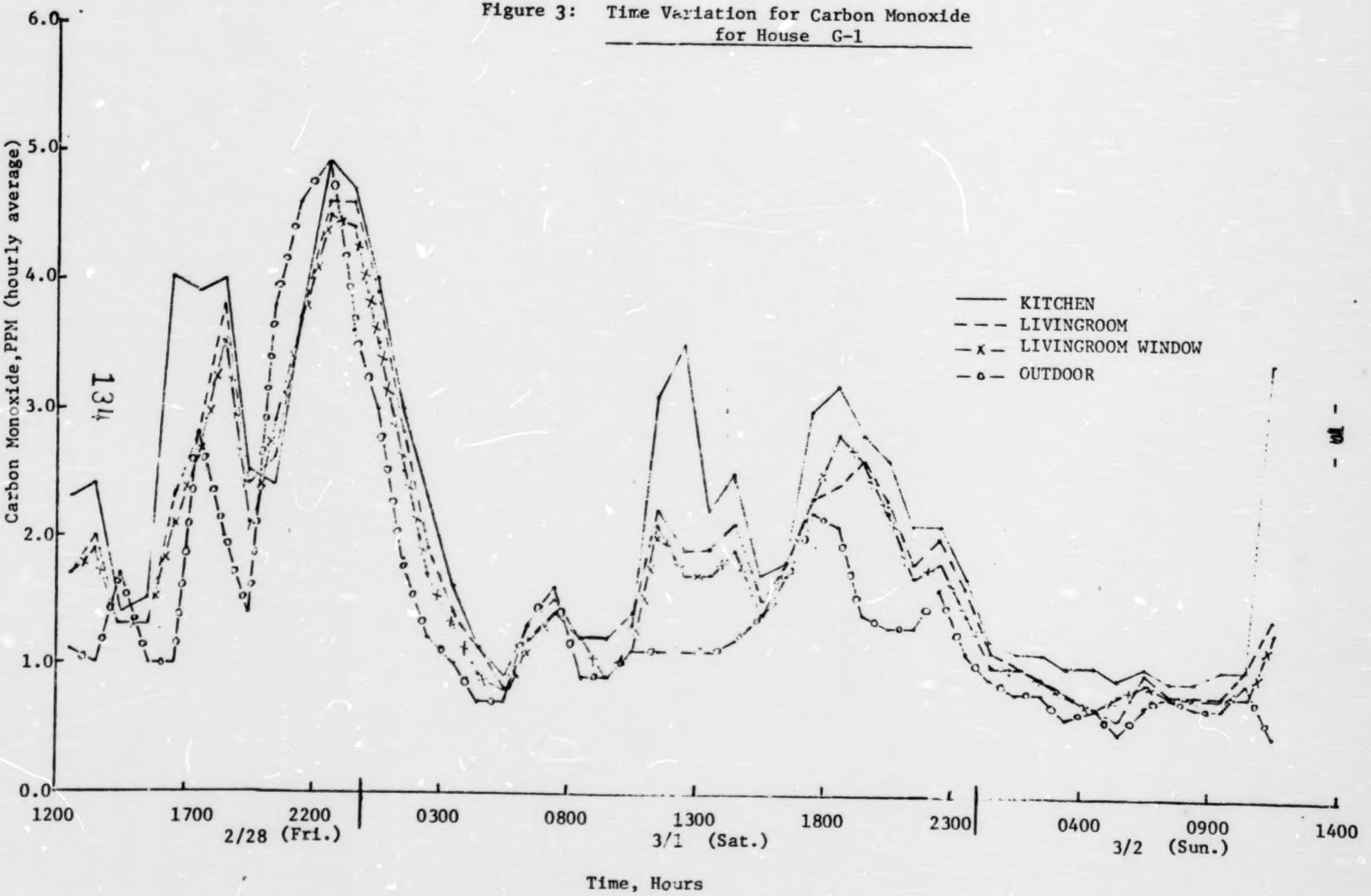
In spite of the limited scope of this study, the results have proved to be most interesting, and much could be said about their significance. However, for the purposes of this report, only the most readily apparent points will be discussed.

4.1 Gas-Fired Homes

4.1.1 House G-1

Figure 3 presents the CO history of this house for the 48 hour period from noon on February 28 (Friday) to noon on March 2 (Sunday). Figure 4 shows a portion of this same record between approximately 3 p.m. and midnight on February 28, but based on individual 5-minute values instead of one hour averages. In Figure 3, it is evident that kitchen sources dominate the CO picture in the house between 1600 and 1800 on February 28. A small outdoor peak at 2.8 PPM during this period, undoubtedly the result of homeward-bound traffic, was insufficient to raise indoor concentrations above those caused by kitchen sources. However, at about 2000 outdoor CO levels exceeded those indoors, and indoor concentrations began to respond to

Figure 3: Time Variation for Carbon Monoxide for House G-1



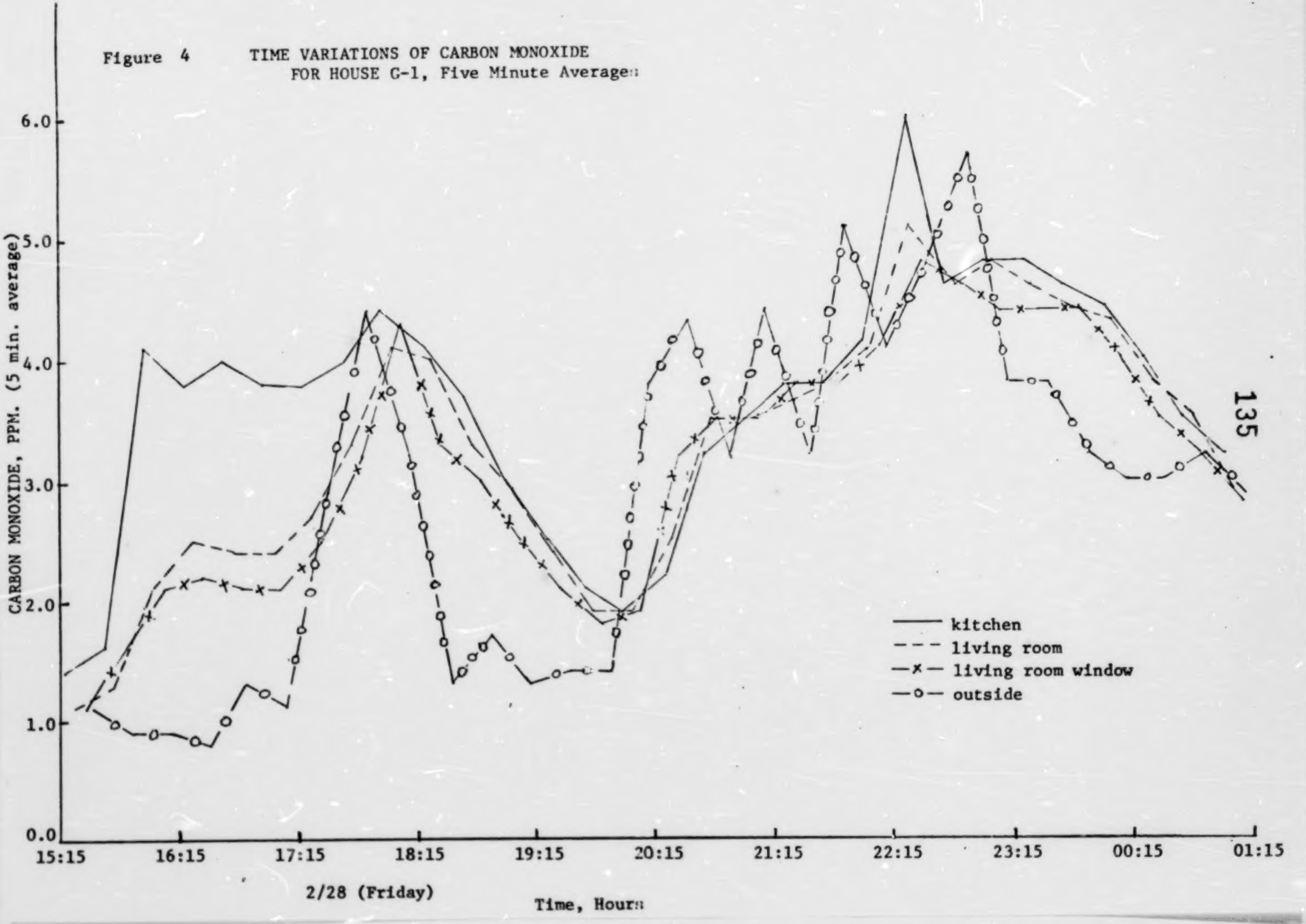


Figure 4 TIME VARIATIONS OF CARBON MONOXIDE FOR HOUSE G-1, Five Minute Averages

the outdoor influence. Reference to Figure #4 shows that the outdoor concentrations are more variable than is apparent from Figure #3 (5-minute values versus one hour averages). In Figure #3, there appears to be some influence of the kitchen shortly after 2200. Figure shows this strong kitchen peak at 6.0 PPM just after 2215.

The indoor-outdoor patterns in the remainder of this record also appear to be logical. The gradient between the various sampling points usually shows the point nearest the window to be at an intermediate value between the kitchen and outdoors. Although these differences are small, the use of a single monitoring instrument and a single calibration for all sampling points assures that these differences are real. Use of individual instruments for each sampling point would not have provided this same degree of assurance.

During the early morning hours on Sunday, March 3, when both indoor and outdoor sources were at a minimum, the kitchen CO levels were always slightly higher than at other locations. This may be the result of some small continuous source in the kitchen, such as the stove pilot lights.

4.1.2 Home G-2

Figure #5 presents the CO history of this gas-fired home between noon on March 4 (Tuesday) and noon on March 6. One significant difference in this home as compared with home G-1 is that the kitchen is at a slightly higher elevation (approximately 1/2 story) than the other part of the house, where samples were taken (see Figure #1). Another difference is the lower outdoor levels of CO at this location.

As in the case of the other gas-fired home (G-1) the kitchen is capable of making a significant contribution to indoor CO levels (see 1500 to 1800 on 3/4, 1800 to 2300 on 3/5 and 0700 to 0900 on 3/6). However, the influence of the kitchen on the family roon is not as great as was

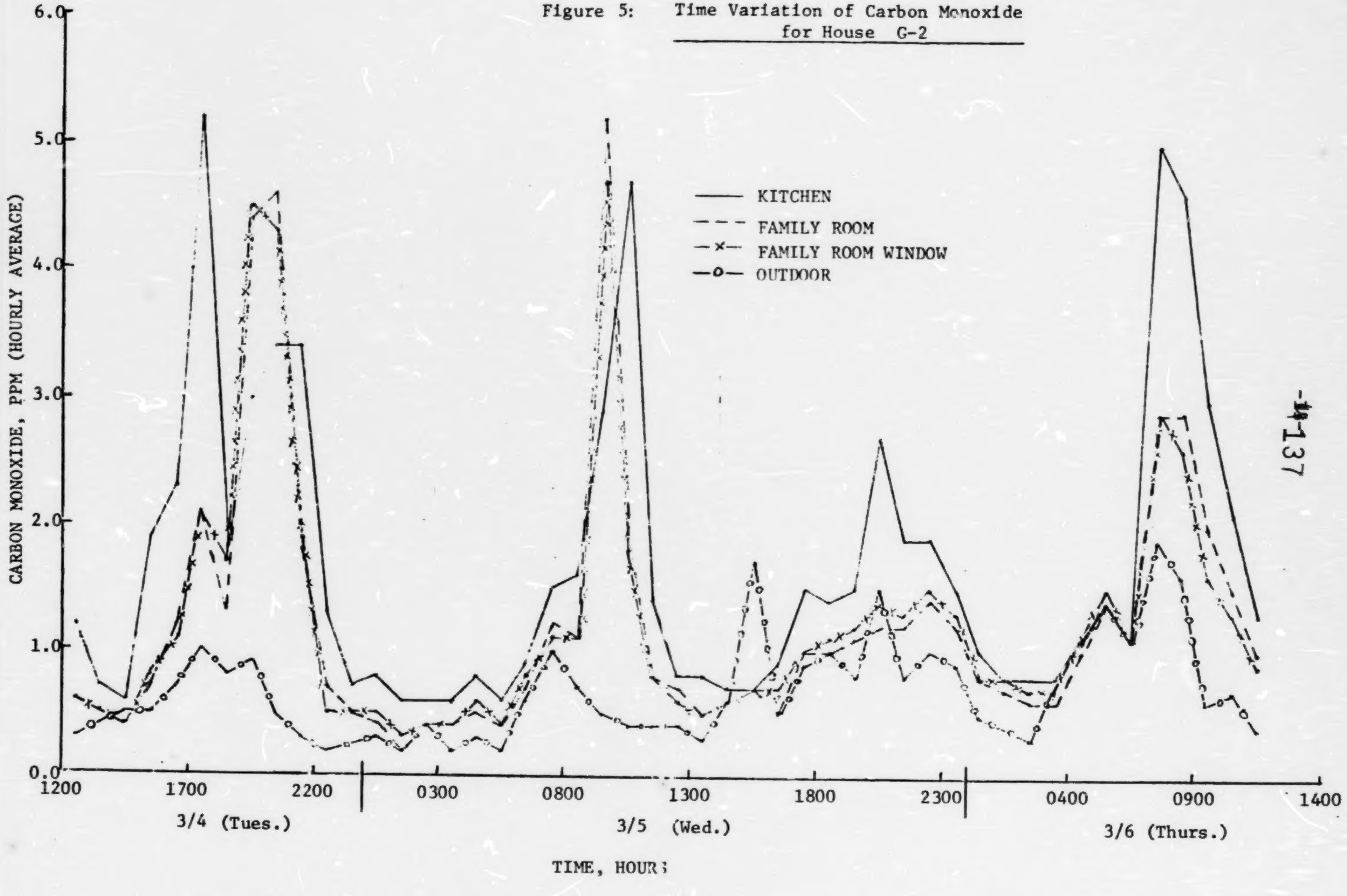


Figure 5: Time Variation of Carbon Monoxide for House G-2

the influence of the kitchen on the living room in home G-1. The difference in elevation between kitchen and family room in home G-2 undoubtedly accounts for this.

The most interesting feature of the results from this house is the strong influence of the attached garage on CO concentrations in the family room and kitchen. Note the periods between 1900 and 2200 on 3/4 and 0900 and 1200 on 3/5. During these periods, the family car was either being taken from or returned to the garage.

4.2 Coal-Fired Homes

As was mentioned earlier, sampling in the coal-fired homes consisted of monitoring for SO_2 and soiling particulate matter in addition to CO. Also, the sampling plan consisted of two indoor and two outdoor sampling locations (see Figure #2).

4.2.1 House C-1

Figures #6 and #7 are the concentration histories at this house for CO and SO_2, respectively for the 48-hour period from noon on March 17 (Monday) to noon on March 19. The most striking features of these records are the high concentrations of CO and SO_2 shown over coincident periods. The ordinate on Figure #6 and Figure #7 had to be compressed to a considerable extent to permit the depiction of the relative indoor and outdoor concentrations. It is clear from these two figures that indoor sources completely dominate the indoor levels of CO and SO_2. A leaky furnace is the only logical source of both CO and SO_2. As soon as the data from this period had been analyzed, a letter was immediately sent to the owner of home C-1 to inform him that levels of CO approaching those which are harmful to breathe (TLV = 50 PPM) had been measured in his house and that TRC recommends a complete furnace inspection before next fall. The period of sampling was rather mild (temperature range in downtown Hartford was 37°F

Figure 6: Time Variation of Carbon Monoxide for House C-1

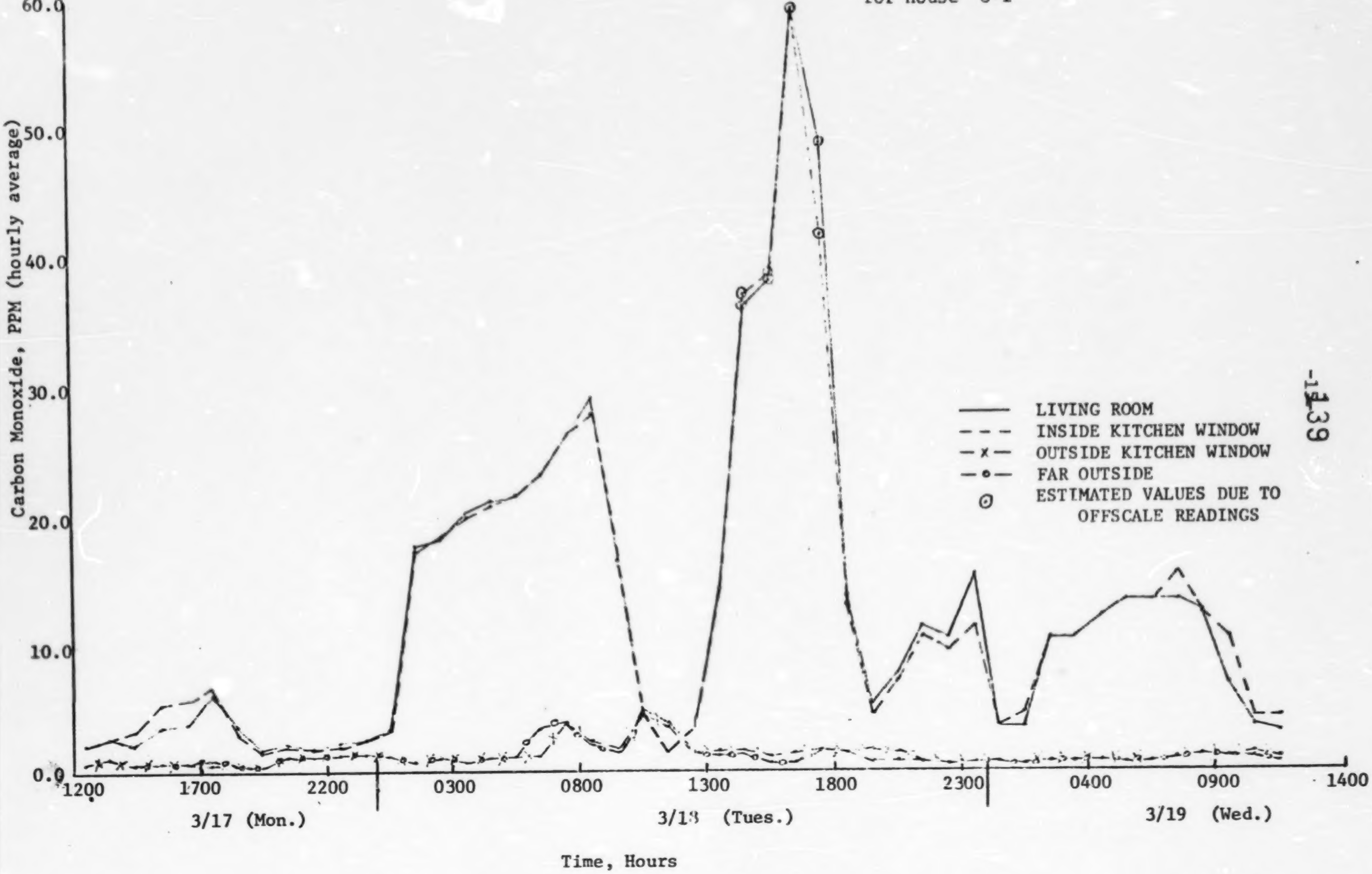
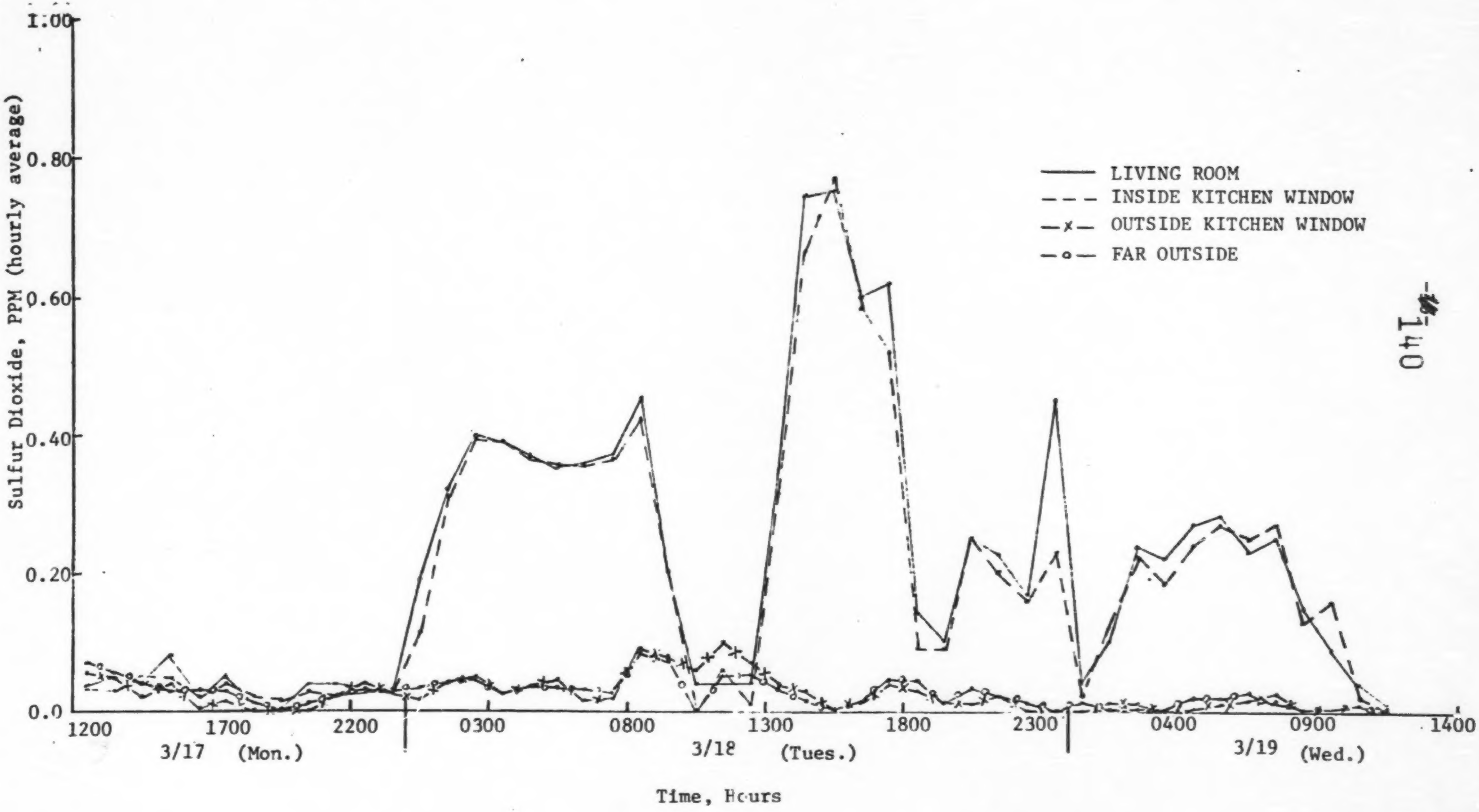


Figure 7: Time Variation of Sulfur Dioxide for House C-1



to 67°F) and it stands to reason that CO exposures were probably even higher during periods of greater furnace use.

Note the close correspondence between the two indoor sampling stations. We believe this to be the result of rapid mixing of indoor air from the hot air register during periods when heated air is entering the house from the furnace.

Figure #8 shows the history for soiling particulate matter for the same period shown in Figures #6 and #7. It is apparent that indoor soiling particulate matter levels are largely dominated by outdoor levels. There does not seem to be any detectable contribution to indoor levels from the furnace, even during those periods of high indoor CO and SO_2 when furnace gases appear to be leaking into the house. At present, we have no explanation for this apparent anomaly.

On several of the occasions when indoor sources dominated the soiling particulate pattern, e.g., at 1100 and 1900 on 3/18, the spot on the sampling tape had a definite yellowish cast and a distinct oily component showing that cooking and/or smoking had a decided influence on these occasions.

4.2.2 House C-2

Figures #9 and #10 are the concentration histories for CO and SO_2 for this house for the 48-hour period between noon on March 22 (Saturday) and noon on March 24. Because of the low concentrations of both CO and SO_2 at this location, the scales have been expanded considerably as compared with Figures #6 and #7

The indoor and outdoor relationships for CO show that, in most cases, outside air quality dominates, and with few exceptions indoor concen-- trations follow. The pattern of SO_2 (Figure #10) is also largely dominated by outside levels. The apparent contribution of SO_2 in the kitchen at

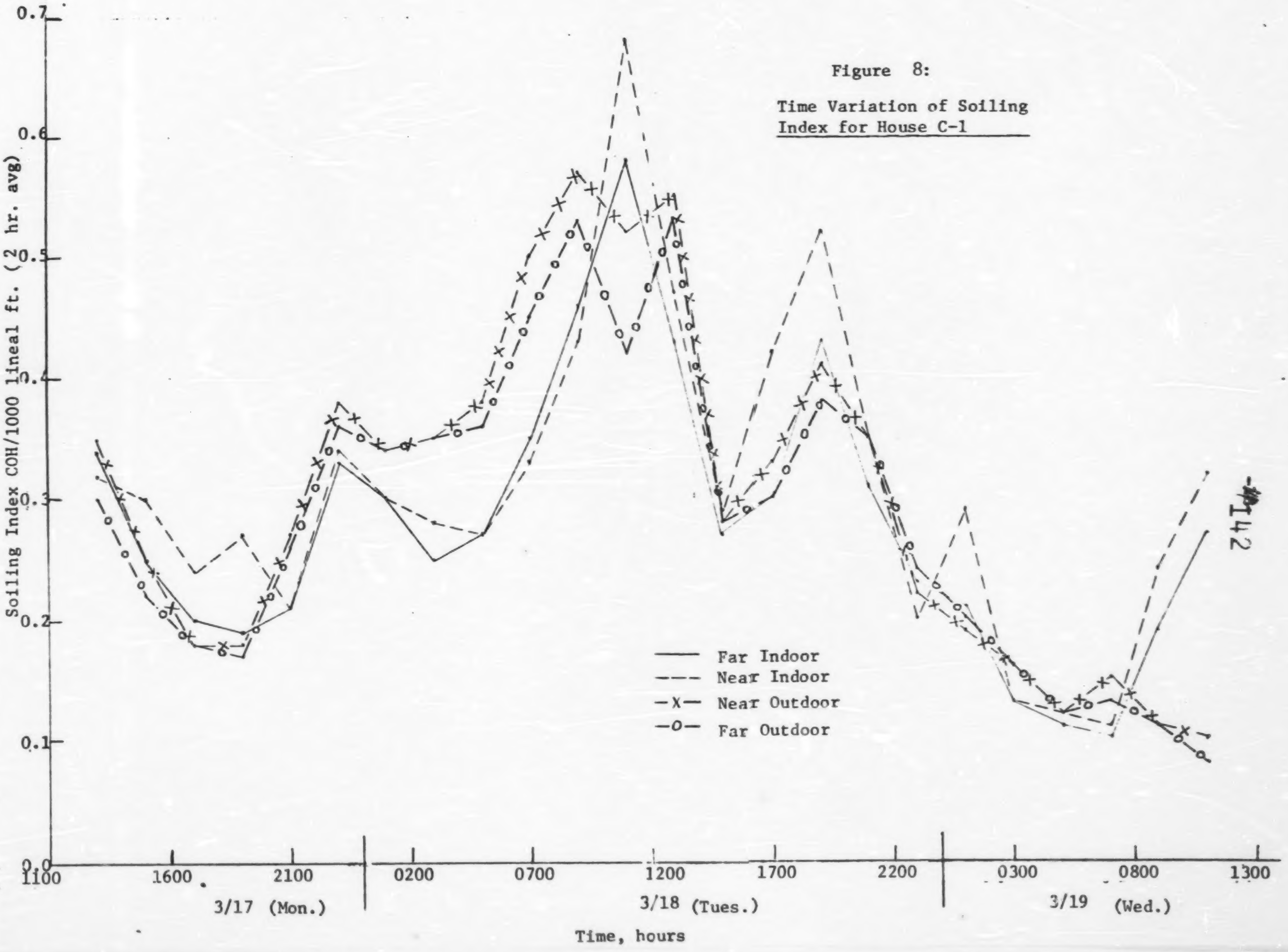
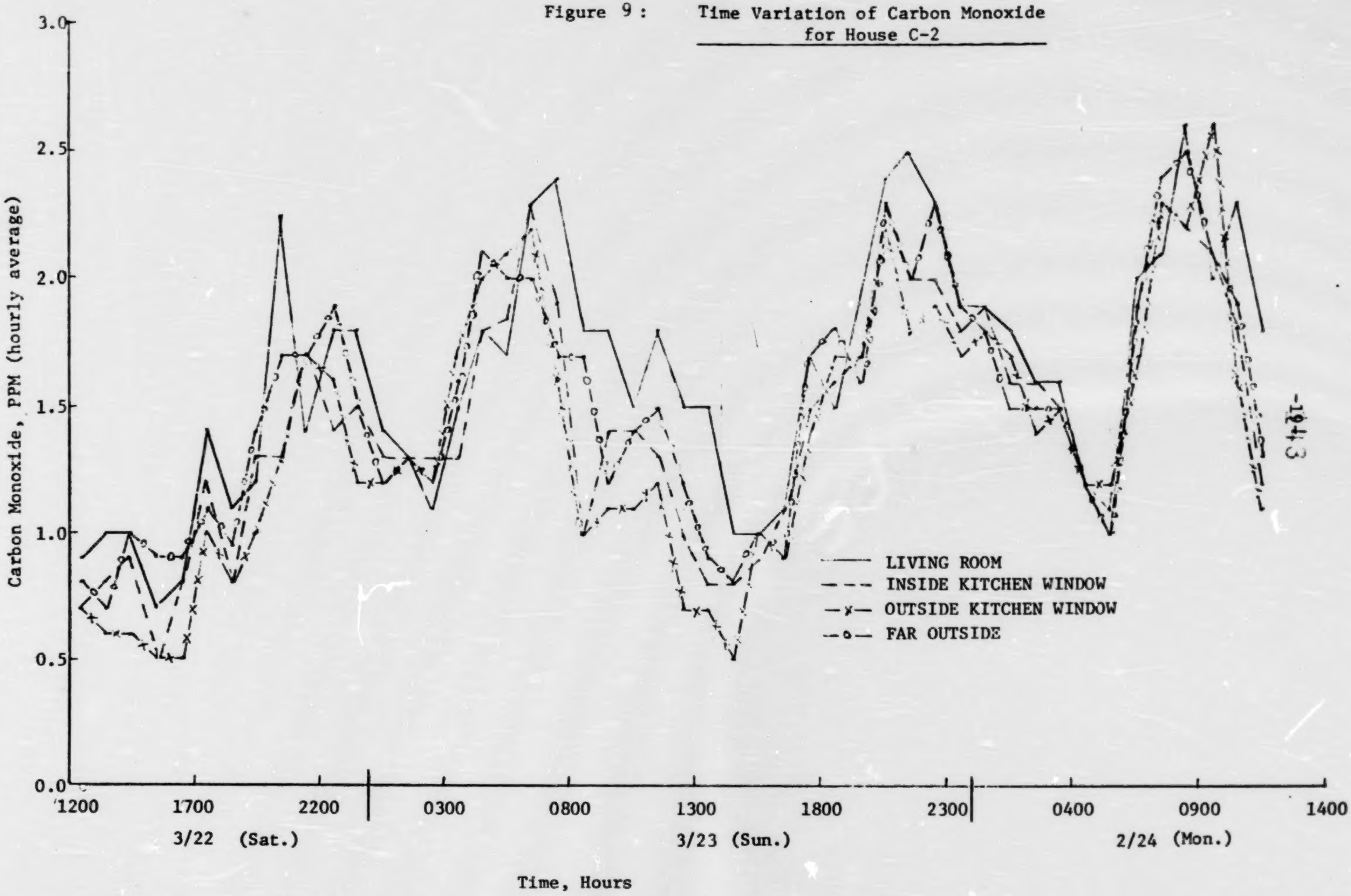


Figure 8:

Time Variation of Soiling Index for House C-1

Figure 9 : Time Variation of Carbon Monoxide for House C-2



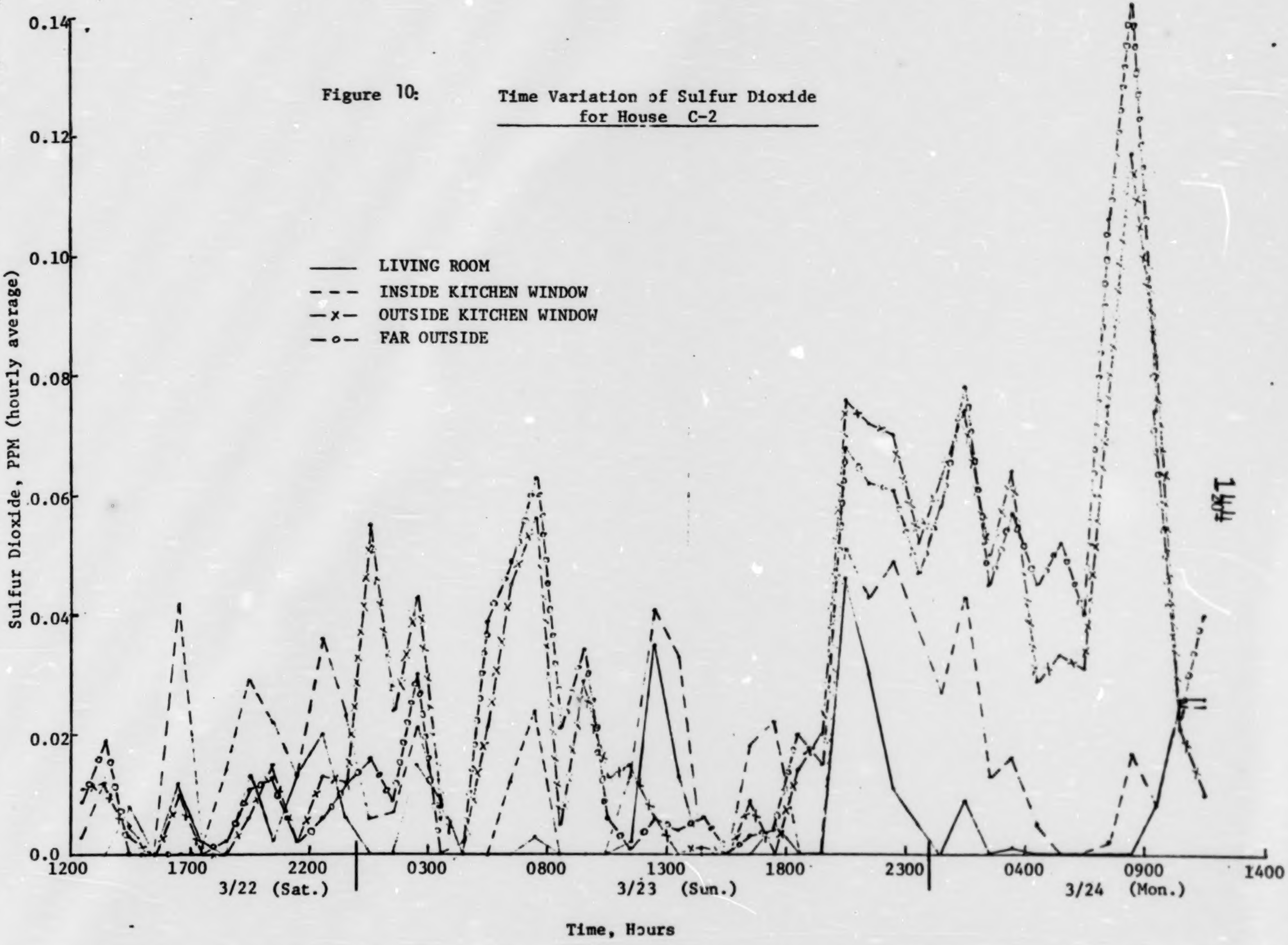
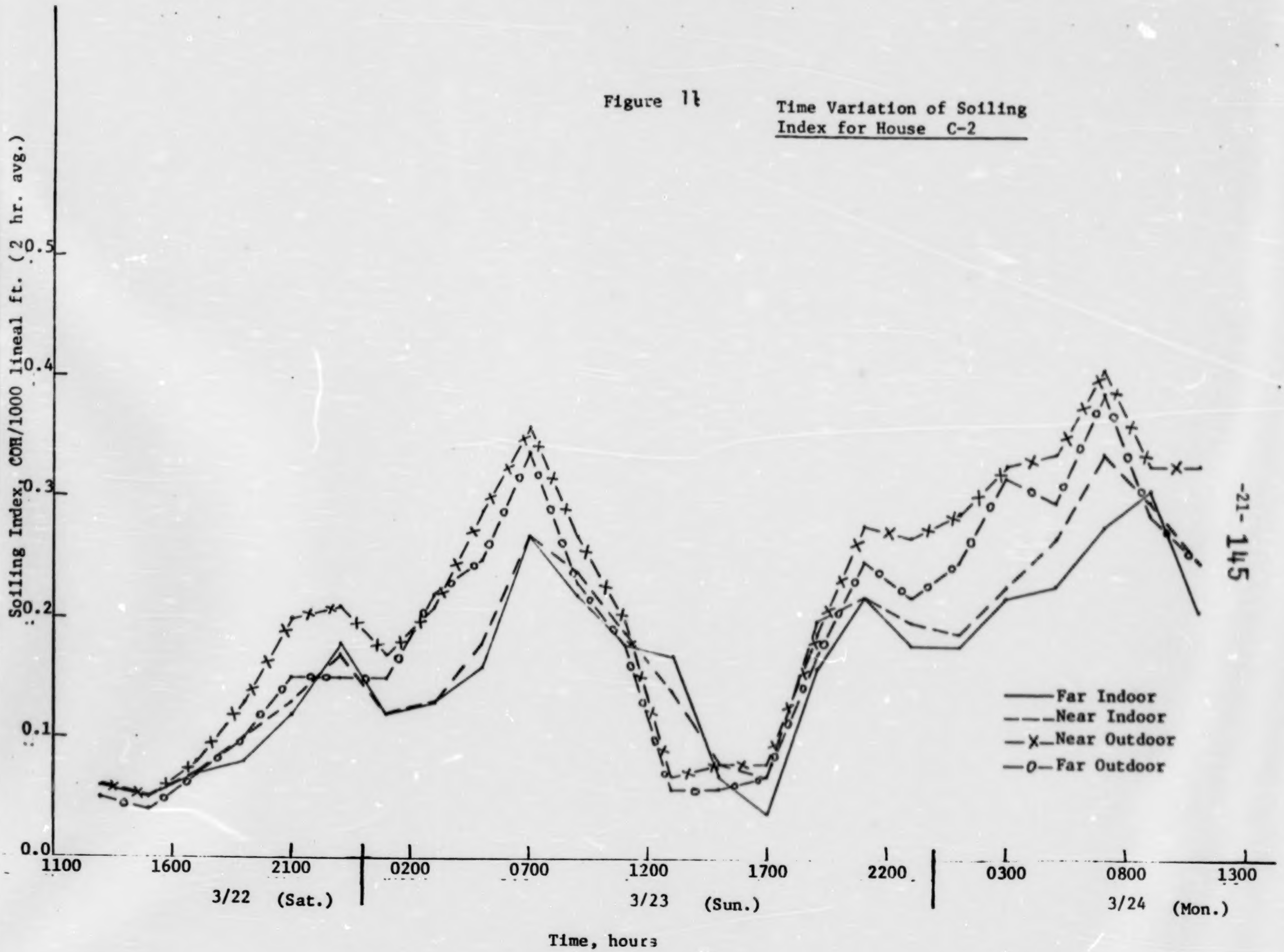


Figure 10: Time Variation of Sulfur Dioxide for House C-2

Figure 11

Time Variation of Soiling Index for House C-2



1630, 1930, and 2230 on 3/22 may be an interference of CO_2 to the conductiometric reading for SO_2 at these low levels.

The most interesting aspect of this record is that it shows an apparent loss of SO_2 as it diffuses into the house. Note the portions of the record between 0400 and 0800 on 3/23 and between 1900 on 3/23 and 1000 on 3/24. There is a definite drop in indoor SO_2 levels between the kitchen window and the living room. The degree of penetration of SO_2 into the house and the conservation of SO_2 as it diffuses into the inner areas of the house appears to decrease with indoor activity and increased outdoor atmospheric stability. The night of March 23 was clear with very low wind speeds. In the hours before dawn essentially no SO_2 could be found indoors although outdoor concentrations were appreciable.

Figure #11 is the concentration history of soiling particulate matter for house C-2 covering the same period as shown in Figure #11 and Figure #12. This figure shows without question that indoor soiling particulate matter is directly related to outdoor concentrations, but that there is some loss of this material as it penetrates and diffuses into the house.

APPENDIX

Meteorological Data

148

WEATHER SUMMARY Sky Code Scale: 1 = Clear 4 = Half Cloudy 7 = Cloudy

Feb. 28	Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Temperature		30	30	30	29	30	30	30	30	30	31	32	34	36	36	39	39	37	33	31	30	30	28	27	26
Wind	Avg. Speed	11	13	13	12	12	11	11	15	16	15	14	13	10	9	7	6	6	6	7	4	3	3	3	5
	Direction	N	N	N	N	N	N	N	N	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE/E	E	E	NE	NE	NE	NNW
	Max. Gust	22	20						23	26	23	21	20												
Precipitation																									
Sky Code		7	7	7	7	7	6	6	5	4	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1

Daily Summary Precipitation: Total 0 inches Snowfall 0 inches Snow on ground at midnight 7 inches

Mar. 1, 1969

Temperature		25	26	25	24	24	23	23	24	26	31	33	36	37	36	35	37	34	32	30	29	28	28	29	28
Wind	Avg. Speed	3	6	4	6	6	8	5	8	10	11	9	5	7	8	9	7	10	9	9	8	8	8	7	8
	Direction	N	N	N	N	N	N	N	N	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	E	NE	NE	NE	NE	NE
	Max. Gust																								
Precipitation																									
Sky Code		2	5	7	5	5	5	5	5	4	4	2	2	2	2	2	2	2	2	2	3	3	5	7	7

Daily Summary Precipitation: Total 0 inches Snowfall 0 inches Snow on ground at midnight 6 inches

Mar. 2, 1969

Temperature		28	28	28	29	29	30	30	31	32	33	35	36	36	35	35	35	35	33	33	32	33	33	34	32
Wind	Avg. Speed	9	8	9	11	11	13	13	14	13	13	15	18	20	20	19	20	20	19	19	20	19	20	19	19
	Direction	N	N	N	N	N	N	N	N	N	N	NE	NE	NE	NE	NE	NE	N	N	N	N	N	N	N	N
	Max. Gust						24	23	24	24	22	22	26	32	33	31	34	35	30	30	30	34	35	44	36
Precipitation							T	T							T										
Sky Code		7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7

Daily Summary Precipitation: Total T inches Snowfall T inches Snow on ground at midnight 5 inches

Mar. 3, 1969

Temperature		32	33	33	32	32	31	31	31	30	29	30	31	32	33	37	40	38	37	36	35	35	35	34	35
Wind	Avg. Speed	21	21	21	22	24	25	24	24	24	24	23	24	22	21	19	15	14	16	16	15	13	13	13	11
	Direction	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	NW	NW	NW	NW	NW	NW	NW	NW
	Max. Gust	33	36	36	41	38	36	39	37	35	38	37	36	36	42	32	31	22	25	26	24	22	22	22	22
Precipitation					T	T	T	.01	.01	.01	.04	.08	.08	.05	.02										
Sky Code		7	7	7	7	7	7	7	7	7	7	7	7	7	6	7	7	7	7	7	7	7	7	7	7

Daily Summary Precipitation: Total 0.30 inches Snowfall 5.0 inches Snow on ground at midnight 9 inches

WEATHER SUMMARY

Sky Code Scale: 1 = Clear 4 = Half Cloudy 7 = Cloudy

Mar. 4	Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Temperature		35	35	34	33	34	33	34	34	38	40	41	41	41	43	41	40	39	35	33	31	28	26	25	23
Wind	Avg. Speed	9	10	10	11	9	10	8	9	7	12	8	12	13	13	15	15	15	15	18	17	16	16	17	16
	Direction	NW	NW	NW	NW	NW	NW	N	N	NW	NW	N	N	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW
	Max. Gust										20		20		25	24	26	26	29	28	28	27	24	28	24
Precipitation																									
Sky Code		7	5	4	2	2	1	1	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1

Daily Summary Precipitation: Total 0 inches Snowfall 0 inches Snow on ground at midnight 5 inches

Mar. 5, 1969		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Temperature		22	21	20	20	20	18	18	18	21	22	24	27	27	27	28	30	28	27	26	25	24	24	22	22
Wind	Avg. Speed	11	10	9	10	9	13	7	13	11	12	10	12	10	16	15	10	10	8	9	7	2	2	3	3
	Direction	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	N	NW	NW	NW	NW	NW	NW	NW	NW	VRBL	VRBL	W	W
	Max. Gust	24					20			21	21	23	22	26	28	30	26	29		20					
Precipitation																									
Sky Code		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Daily Summary Precipitation: Total 0 inches Snowfall 0 inches Snow on ground at midnight 4 inches

Mar. 6, 1969		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Temperature		22	21	21	21	20	21	22	23	25	29	33	38	36	39	40	41	40	39	37	36	34	32	31	32
Wind	Avg. Speed	2	4	5	2	5	3	3	2	3	5	4	4	3	3	3	4	4	3	2	1	1	1	2	5
	Direction	W	W	W	W	W	W	W	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SE	S	NE	NE	NE
	Max. Gust																								
Precipitation																									
Sky Code		1	1	2	2	4	4	4	3	3	3	3	3	3	3	2	2	2	2	2	2	4	6	7	7

Daily Summary Precipitation: Total 0 inches Snowfall 0 inches Snow on ground at midnight 3 inches

Wind	Avg. Speed																								
	Direction																								
	Max. Gust																								
Precipitation																									
Sky Code																									

Daily Summary- Precipitation: Total ___ inches Snowfall ___ inches Snow on ground at midnight ___ inches

WEATHER SUMMARY Sky Code Scale: 1 = Clear 4 = Half Cloudy 7 = Cloudy

Mar. 17	Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Temperature		32	32	31	30	29	29	29	32	39	42	45	48	50	51	52	53	54	53	52	46	44	44	44	44
Wind	Avg. Speed	2	2	2	1	3	1	4	8	6	3	4	4	6	9	6	5	4	4	1	5	2	1	1	2
	Direction	NW	SW/NW	SW	SW	SW	W	S	S	S	SW	SW	SW	S	SW	SW	SW	SW	W	SW	SW/S	S	S	S	S
	Max. Gust																								
Precipitation																									
Sky Code		1	1	1	1	1	2	4	2	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2

Daily Summary Precipitation: Total 0 inches Snowfall 0 inches Snow on ground at midnight 0 inches

Mar. 18, 1969																									
Temperature		41	42	41	42	42	41	41	43	47	51	54	60	64	65	67	66	64	58	53	49	46	44	40	38
Wind	Avg. Speed	3	3	2	2	5	6	4	4	1	3	5	4	3	2	4	4	2	4	3	6	5	5	6	7
	Direction	S	S	S	S	S	S	S	S	SE	SE	SE	SE	S	S	SW	SW	SW	S	S/E	E	NE	NE	NE	NE
	Max. Gust																								
Precipitation																									
Sky Code		3	4	4	4	5	5	5	5	4	2	1	1	1	1	1	1	1	2	1	1	1	1	2	3

Daily Summary Precipitation: Total 0 inches Snowfall 0 inches Snow on ground at midnight 0 inches

Mar. 19, 1969																									
Temperature		37	37	37	37	37	38	39	40	41	42	44	46	48	48	46	45	45	43	43	43	42	41	41	39
Wind	Avg. Speed	11	9	9	10	9	9	12	10	11	13	10	12	15	14	15	13	9	10	7	7	6	6	4	4
	Direction	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	N	N	N	N	N	NE	NE	NE	NE	NE	NE	NE	NE	NE
	Max. Gust										21	26		22	22	20									
Precipitation																									
Sky Code		2	4	7	7	7	7	7	7	7	7	5	3	2	7	7	7	7	7	7	7	7	7	7	7

Daily Summary Precipitation: Total T inches Snowfall 0 inches Snow on ground at midnight 0 inches

Mar. 20, 1969																									
Temperature		39	39	38	38	38	39	40	40	41	44	44	45	45	44	44	44	46	45	42	41	40	41	40	39
Wind	Avg. Speed	4	6	5	3	5	3	3	2	4	2	3	5	5	4	3	4	5	5	10	9	6	5	8	11
	Direction	N	N	NE	N	N	N	N	NE	NE	NE	NE	NE	NE	SE	SE	SE	S	S	S	S	S	S	S	S
	Max. Gust																								22
Precipitation																									
Sky Code		7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7

Daily Summary Precipitation: Total T inches Snowfall 0 inches Snow on ground at midnight 0 inches

WEATHER SUMMARY Sky Code Scale: 1 = Clear 4 = Half Cloudy 7 = Cloudy

Mar. 22 Hour		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Temperature		43	41	40	40	40	40	40	39	42	44	45	43	44	44	43	44	43	43	42	41	39	38	37	36
Wind	Avg. Speed	4	4	1	1	4	4	1	13	*4	* 7	*5	11	12	12	11	12	12	*11	6	6	9*	*4	*2	4
	Direction	SW	SW	SW	SW	S	SW	W	NW	W	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	VRBL	NW	NW
	Max. Gust								20				23	22	21	26	26	20							
Precipitation																									
Sky Code		5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	4	2	1	1	1	1	1	1

Daily Summary Precipitation: Total 0 inches Snowfall 0 inches Snow on ground at midnight 0 inches

Mar. 23, 1969 *Unrepresentative Speeds Gage Blocked by High Bldgs. W & NW

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Temperature		36	36	36	31	30	31	34	38	40	44	50	54	54	55	54	55	55	51	49	46	42	40	38	37
Wind	Avg. Speed	3	3	3	2	2	2	2	2	3	3	2	2	2	6	5	2	2	6	6	6	6	4	2	5
	Direction	NW	NW	NW	S	S	S	S	S	SE	SE	VRBL	VRBL	VRBL	NW/W	VRBL	VRBL	SW	S	S	S	S	S	S	S
	Max. Gust																								
Precipitation																									
Sky Code		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Daily Summary Precipitation: Total 0 inches Snowfall 0 inches Snow on ground at midnight 0 inches

Mar. 24, 1969

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Temperature		37	36	36	35	35	35	35	37	44	46	46	47	46	46	47	47	46	45	44	43	42	42	42	41
Wind	Avg. Speed	5	5	5	6	5	5	5	4	4	5	6	6	5	4	4	7	7	8	9	10	4	4	9	14
	Direction	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	SE	S	SE	SE	E	E	SE	SE
	Max. Gust																								24
Precipitation																		T	T	.02	.05	.09	.07	.11	.11
Sky Code		1	1	1	2	2	2	3	4	4	4	7	7	7	7	7	7	7	7	7	7	7	7	7	7

Daily Summary Precipitation: Total .45 inches Snowfall 0 inches Snow on ground at midnight 0 inches

Wind	Avg. Speed																								
	Direction																								
	Max. Gust																								
Precipitation																									
Sky Code																									

Daily Summary. Precipitation: Total ___ inches Scowfall ___ inches Snow on ground at midnight ___ inches